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THE COMPOSITION OF FUSEL OIL FROM BEET MOLASSES*

By M. C. Boswell, '00, and J. L. Gooderham, '11.

The published proximate analyses of fusel oil are very few and mostly relate to the distillates from potatoes and corn. This arises from the fact that, until comparatively recent years, fusel oil from any source was regarded as more or less valueless. In Canada, after legislation put a premium on its destruction, this product was allowed to run away in drains or used as a constituent of a cheap burning fluid. The numerous purposes to which it is now applied and for which it is indeed indispensable, have changed this custom so that it has become four or five times as valuable as the alcohol from which it is separated.

The production of fusel oil from the fermentation of beet molasses depends industrially on a supply of crude material from beet sugar refineries, which did not come into existence on a large scale in Canada until about seven years ago. An alcohol plant, capable of handling from 30,000-40,000 tons of molasses per annum, was established in Toronto in 1905, and very considerable quantities of fusel oil have since been produced, for which a home use, or an export value, has to be found.

The researches of Ehrlich[1], carried on since 1903, ultimately led to the conclusion that the production and composition of fusel oil depend on the character of the substance fermented, mainly with relation to the quantities of leucine and isoleucine present. As beet molasses mash differs very widely from that from potatoes or grain, it might be expected that a corresponding difference would be noted in the quantities and proportions of the amyl alcohols. The particular composition of beet molasses fusel oil is hence a question of considerable technological importance.

The fusel oils of commerce differ very widely in their general characteristics, such as color, specific gravity and solubility in water, being influenced not only by the nature of the material operated on, but by the form of distilling apparatus, the process followed, and the care of the operator. The excise authorities generally look

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[1] Summarized in Harden's *Alcoholic Fermentation*, 1911, pp. 75-82.

sharply after the presence of ethyl alcohol, and their requirements regarding this affect the presence of other alcohols soluble in water. In the United States, the official and commercial regulations confine the term "crude fusel oil" to that from which the lower alcohols have been so far removed by washing, that a loss of not more than 10 per cent. is realized by agitation with an equal bulk of water. The term is thus used in this paper. Hence the percentage of water-soluble alcohols in fusel oil will depend, to some extent, on whether the manufacturer has found it necessary to wash his oil in order to meet the excise requirements respecting ethyl alcohol.

The oil examined was amber in color. It was found that the substance or substances causing the color were soluble on shaking in dilute caustic soda. Traces of iron and copper were found, due probably to contact with these metals in the process.

The specific gravity of the sample, taken by the pycnometer, at 15° C. was 0.8370. This is somewhat higher than the figures given for fusel oil from corn, which differ widely as stated by various authorities. Worden[2] gives the range for ordinary samples of washed oil as between 0.810 and 0.835. It is evident that this character will be largely influenced by the amount of water dissolved in the oil, and also by the lower alcohols which have escaped the washing-out process.

In the fusel oil examined, the lower alcohols (ethyl, propyl and butyl) were roughly estimated by agitating equal volumes of oil and water thoroughly in a measuring tube, and noting the increase in volume of the water layer. This amounted to 8 per cent. In a similar manner the amount of water was determined approximately by agitating 10 cc. of the oil with 100 cc. of petroleum benzine and measuring the water layer. This amounted to 5 per cent. Then 500 cc. of crude unwashed fusel oil was thoroughly dried over anhydrous sodium sulphate and fractionated repeatedly until the volumes of the fractions remained constant. The result was as follows:

I.	II.	III.	IV.	V.	VI.	VII.
75°–80°	80°–85°	85°–90°	90°–105°	105–115°	115°–120°	120°–125^{c}
7 cc.	18 cc.	6.5 cc.	11 cc.	22 cc.	27 cc.	29 cc.

VIII.	IX.	X.	XI.
125°–128°	128°–130°	130°–133°	residue
45cc.	260cc.	33cc.	10cc.

TOTAL, 473.5 cc. WATER, 20.0 cc. LOSS, 6.5 cc.

A sample of the crude oil was thoroughly agitated with water, and the oil separated and dried: 500 cc. of this on fractionation gave the following:

I.	II.	III.	IV.	V.	VI.
75°–80°	80°–85°	85°–90°	90°–110°	110°–115°	115°–120°
none	none	very little	10 cc.	10 cc.	25 cc.

VII.	VIII.	IX.	X.	XI.
120°–125°	125°–128°	128°–130°	130°–133°	residue
40 cc.	75 cc.	278cc.	51 cc.	10 cc.

TOTAL, 499 cc. LOSS 1 cc.

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[2] Worden, *Nitro-Cellulose Industry*, I, 208.

On comparing the results of the two fractionations it will be noted that fractions I, II and III have practically disappeared from the washed oil. These were identified, as will be shown later, as lower alcohols which are more or less soluble in water.

Although the boiling points indicated the particular alcohols which were present in the various fractions, it was decided to substantiate this by transforming the alcohols into esters. On examining the literature, it was found that the esters of acetic acid were more completely described than those of any other acid, and consequently served best for purposes of identification. Action with acetyl chloride alone was found to be unsatisfactory, yielding a mixture in each case difficult to fractionate, and always leaving a high boiling residue, indicating that the reaction was not one of simple esterification alone.

The method of Einhorn[1] was adopted and proved very satisfactory.

Accordingly 10 grams of each fraction were dissolved in about 60 grams of pyridine, and a little more than the theoretical quantity of acetyl chloride was added. After standing for 6-8 hours the mixture was poured into cold dilute sulphuric acid. The ester which separated as an oil was dried over anhydrous sodium sulphate and fractionated.

The following were the results:

Fraction I (75°–80°).—See table.—The boiling point indicated ethyl alcohol, which was confirmed by the iodoform reaction.

Fraction II (80°–85°).—The b. p. indicated the presence of isopropyl alcohol—b. p. 82.8°. The ester on fractionation boiled chiefly at 90°–94°, the boiling point of isopropyl acetate. This fraction was hence largely isopropyl alcohol.

The boiling points of fractions III and IV, as well as fractions VII and VIII made it difficult alone to decide with certainty as to the particular alcohols present. However, upon transformation into acetic esters, and careful fractionation, it was found possible to identify them.

Fraction III (85°–90°).—As this fraction was very small, it was esterified and added to the ester from fraction IV.

Fraction IV (90°–105°).—The ester distilled chiefly between 110°–120°. It was hence the isobutyl ester—b. p. 115°–117°. A little isopropyl, and traces of amyl esters, were also detected.

Fraction V (105°–115°).—The b. p. indicated the presence of isobutyl alcohol—b. p. 108°. The largest portion of the ester was recovered at 110°–120°, the temperature being very constant at 115°–117°, indicating isobutyl ester. A very small quantity of normal butyl ester, with a boiling point of 125°, was obtained. This fraction hence consisted chiefly of isobutyl alcohol with some normal butyl alcohol.

Fraction VI (115°–120°).—The b. p. indicated the presence of normal butyl alcohol—b. p. 117°. The main portion of the ester came over at 120° to 130°; mostly at 125°, the boiling point of the

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[1] Liebig's *Annalen*, **301**, 95, Einhorn.

n. butyl ester. Some methyl normal propyl carbinol ester, with a boiling point of 133°–135°, was recovered also. This fraction hence consisted chiefly of *n.* butyl alcohol with some methyl normal propyl carbinol.

Fraction VII (120°-125°).—The ester of this fraction on distillation separated very sharply into two fractions, the larger with b. p. 133°-136° indicating methyl normal propyl carbinol ester, and the smaller with b. p. 138°–139° indicating isoamyl ester. Hence, this fraction consisted chiefly of methyl *n.* propyl carbinol with some isoamyl alcohol.

Fraction VIII (125°–128°).—A small portion of the ester came over between 130° and 137°, containing some methyl *n.* propyl carbinol ester. The largest fraction, which was very constant, distilling between 137°–140°, represented the isoamyl ester. This fraction was chiefly isoamyl alcohol, with a little methyl *n.* propyl carbinol.

Fraction IX (128°–130°).—The b. p. indicated the presence of active amyl alcohol, b. p. 128.5°. Practically all the ester came over between 141° and 142°, being the boiling point of active amyl ester, with a small amount of the isoamyl ester, which boils at 137°–140°. This fraction was hence chiefly active amyl alcohol, with a small amount of isoamyl alcohol.

Fraction X (130°–133°).—The b. p. indicated the presence of isoamyl alcohol, b. p. 131.5°. Practically all the ester came over between 138°–140°, proving it to be the isoamyl ester, with a small quantity of active amyl ester. This fraction hence consisted of isoamyl alcohol with some active amyl alcohol.

The Residue (XI), which amounted to 10 cc., was placed in a small flask and distilled. About 8 cc. came over below 150°; a very little up to 180°; and about 1½ cc. was left in the flask. This last residue appeared to have decomposed with the production of brownish vapor. The 8 cc. that came over was esterified and the ester fractionated, and found for the greater part, to distil between 135°–140°, being the boiling point of the isoamyl ester. That which was collected at 140°–150°, and was fairly constant between 141°–142°, was the active amyl ester. Very little came over above 150°, but if a sufficient quantity had been available, would probably have been found to consist of the hexyl and heptyl esters. This residue hence consisted of isoamyl alcohol and active amyl alcohol with probably small quantities of higher alcohols.

There were no semi-solid substances observed toward the end of the operation as has sometimes been the case with fusel oil from corn.

Ten grams of fusel oil were titrated against a standard potash solution using phenolphthalein as the indicator. 100 grams of fusel oil contained 4.5 cc. normal acid. This is equivalent to 0.5 per cent. free acid in the oil, calculated in C_5H_{11}—COOH as a basis.

Ten grams of fusel oil were boiled with 75 cc. of 0. 5 N.KOH for one hour, under a reflux condenser. After cooling, the excess of alkali was titrated against standard acid.

One hundred grams of oil contained 18.4 cc. of normal free acid and acid from esters. Of this quantity, 4.5 cc. were free fatty acids, while the balance (13.9 cc.) represented the acids from the esters. Using $C_5H_{11}COOC_5H_{11}$, the amyl ester of capronic acid, as a basis for calculation, this is equivalent to 2.5 per cent. ester in the oil.

The bases present in the oil were separated in the usual manner. The amount was too small for purification and estimation. However, the distinctive odor of pyridine was recognized.

Furfurol could not be detected.

Consequently, "the composition of fusel oil from beet molasses" may be summarized as follows:

		Cc. from 500 cc.	Per cent.
Ethyl alcohol		5	1
Isopropyl alcohol		20	4
Isobutyl alcohol		30	6
n. Butyl alcohol		30	6
Amyl alcohols	Methyl *n.* propyl carbinol	40	8
	Active amyl alcohol	210	42
	Isoamyl alcohol	130	26
Fatty acids		2.5	0.5
Esters of the fatty acids		12.3	2.46
Pyridine and other bases		Present	Present
Hexyl alcohols, etc		Traces	Traces
		479.8	95.96
Water		20.0	4.00
Total		499.8	99.96

This composition does not present any marked difference of practical importance from that given for corn by Le Bel,[1] and largely quoted, which is as follows:

	Per cent.
Normal propyl alcohol	3.69
Isobutyl alcohol	15.76
Amyl alcohols	75.85
Hexyl alcohols	0.13
Free fatty acids	0.16
Fatty acid esters	0.30
Terpines and terpine hydrates	0.08
Furfurol, heptyl alcohol and bases	0.02
	95.99

The amount of total amyl alcohols, which, industrially, is the chief point, shows a difference of only 0.15 per cent. The respective figures for butyl alcohols differ by 3.76 per cent., though the propyl closely corresponds. This is, however, of little importance, as it shows only that one sample of oil was washed more than the other.

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[1] Maercker's *Spiritusfabrication*, p. 53.

THE PRINCIPLES OF SCIENTIFIC MANAGEMENT*

By Frederick W. Taylor, M.E., Sc.D.

(On the occasion of his visit to Toronto to address the Canadian Club, Dr. Taylor postponed his return to Philadelphia long enough to meet the members of the Engineering Society in Convocation Hall, and to address them on the subject to which he has devoted so much of his time and energies. Thier interest, evoked by Frank B. Gilbreth in his lecture entitled, "The Place of Motion Study in Scientific Management," delivered in March of last year, was keenly in evidence, and a few hours' notice furnished a large undergraduate audience, together with a few of the graduates and others. It is regrettable that the necessary hasty arrangements prevented a wider representation from the city's industries.

The following is an extracted form of one of the most valuable and interesting addresses delivered to this Society in many years.—Ed.)

In his opening remarks Dr. Taylor presented his subject as referring principally to workers of co-ordinated industry, in distinction to isolated workmen, it being applicable only to the former.

Nineteen of every twenty workmen believe that it is to their best interest to turn out as little rather than as much work as possible. It is the most serious fallacy that possesses our working class, and is attributable to two causes, for neither of which are the workmen themselves to blame.

First, if it be suggested to a group of workmen that they double their output, they reply that the procedure would throw one-half of their fellow-workers out of employment. To them it appears self-evident, and others, among whom are many of our philanthropists, uphold the belief, heralding over-production as one of the greatest social evils conducive to national idleness. It is immensely true in every trade, so its followers believe, that in going slow, their interests are advanced. Any device, therefore, tending to increased output is rebelled against by this deeply rooted nature.

No more fallacious than such belief exists, and it is borne out by history everywhere, with but one exception, that the introduction of such a device or system, into any trade, instead of forcing men out of work, has provided more work for men of that trade. The exception is in farming. Improved processes in the United States have reduced the providers of food supplies from eighty per cent. in years past to thirty-five per cent. at the present time, because the human capacity for food does not increase from generation to generation. This is the only instance where such a condition obtains.

As an illustration of the effect in other forms of labor, Dr. Taylor referred to the cotton industry, its history being comparatively older and its evolution more spectacular. The power loom was invented early in the last quarter of the eighteenth century, but the year 1840 witnessed the climax of its introduction, after a struggle many years in duration, to gain entrance into the manufacturies. In Manchester, Eng., the workmen felt that these looms would throw 3,500 of their 5,000 men out of work, and they strongly resented such outside intervention between them and their daily bread. Conditions were grave, as it was most difficult in those days to change one's trade, or even to move from one works to another. No alternative means of livelihood presented itself. The result was clear and concise. They forced the establishments, destroyed the looms, and maltreated the operators. Their rioting, however, did not affect the entrance of the loom into the industry.

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* Before the Engineering Society, January 21st, 1913.

Be the means what it may, bitter opposition, adverse legislation, public opinion, trade unions—all forces are powerless and futile in defeating the introduction of labor-saving development, and the effect is frequently that of accelerating its use.

The speaker stated that there is great opposition from labor leaders to Scientific Management, but since that opposition has become open and strong, Scientific Management has gone ahead more rapidly.

The result in the case of the cotton industry in the three-quarter century that has elapsed has been that the workmen have been proven wrong in their convictions. Has the increase of output thrown laborers out of work? In 1840 there were 5,000 workers. At the present time there are about 265,000 employed at the same work in Manchester. For every yard of cloth in 1840 there are now five hundred yards manufactured, though the population of England has not more than doubled within that time.

"There is a broad meaning back of it all. Wealth need only be brought into the world, for the world to use it. Although there are undeniable cases of over-production, they are abnormities, due to a general cause—the world undertaking a greater number of new enterprises than available capital warrants. It is a disease to which the public is susceptible, and the panics of 1873 and 1893 are unforgotten. On the other hand production is necessary to wealth, which is derived from two sources, viz., out of the ground, and by manufacture at the hands of man. The relation of wealth to production should be recognised, particularly by the poorer classes; their impression is erroneous that by far the major part of the bounties of this world are consumed by the wealthy classes. The reverse is the truth.

"The best index of progress in the world is the increase in output per individual, it being a measure of the increase of prosperity of the individual. The 'good old times' slogan indicates the user to be ignorant of conditions, as increase in output per man has provided such a variety of good things of life that the workmen of to-day live as the kings of yesterday. Luxuries of history are considered necessities now."

Reverting to the previously discussed condition in the farming industry, apart from those who provide the food supplies in the United States, sixty-five per cent. of the population may now engage in other industries as against the twenty per cent. years ago. This indicates *increase in output per individual*, which is the object of Scientific Management.

"Soldiering"

The second belief the workman entertains as a reason for going slow, Dr. Taylor emphasizes as being again in no way attributable to the man himself. It is illustrated by the case of a workman being paid $2.50 per day and making 10 pieces a day, entering then upon the piece-work system. The foreman pays him twenty-five cents per piece for the ten pieces which he turns out. Gradually the laborer increases his output, probably reaching twenty pieces per day, thereby doubling the contents of his pay envelope. Both laborer and foreman are well satisfied with the result.

But at the annual meeting of the board of directors, the pay-roll may properly be called for and closely examined. The foreman must explain his action in paying $5.00 per day instead of $2.50 per day. A storm of protest ensues, savouring of competitors' prices and pay-rolls, and resulting in measures to prevent the supposed ruin of the firm's labor market. The foreman is obliged to reduce the workman's salary to perhaps $2.75 per day.

"There are a great many bitter things said against the working man, concerning his selfishness, his tyranny, etc.; some of them are true, but there is just one thing that the working man of our country is not—he is not a fool. It is only necessary to give him one lesson, or at the most two, and he becomes a 'soldier' for life. He studies just how much the management will permit him to earn, and that is the amount of his output."

The fallacy of going slow is of such vital importance that the evil of it cannot be pointed out too strongly. There is not the slightest doubt that this is the greatest evil of the age in England. She is suffering from under-production, not over-production, and no voice is raised in protest. England preceded this continent by a generation in the adoption of the policy of "soldiering," and the result has been detrimental to the reputation of the working man hailing from her shores, although he is, especially the steel worker, the most skilled workman in the world. The speaker cited cases where the laborer from across the seas absolutely refused to increase his output, curtailing it at every turn, thus necessitating drastic measures against his employment. The same thing is going on in England to-day and is the reason for unemployment and poverty. The policy of curtailing output strikes at the very root of the trouble.

"The first step of Scientific Management was to endeavor to prevent this diminishing output, and each succeeding step has been an earnest endeavor to remedy other existing evils in previous forms of management. Scientific Management is no new or untried theory, and is no food for profound suspicion. It is a gradual evolution tested and proven step by step. It is the fruit of many men's ideas. Some years ago over fifty thousand men were working under its principles while the number has probably doubled since that computation was made.

"As in the case of all labor saving devices, the ultimate result is that the general public gets the entire profit. The end of it all is that the whole world is going to profit from it. At first the companies that have introduced it are reaping large profits, many of them more than doubling their output. They are the pioneers, and as such are entitled to the gains."

A workman under Scientific Management immediately increases his wages from 33 to 100%. This increase is not the greatest good to the working people, however, but the change of mental attitude toward work on the one hand and employers on the other is a more important part of their lives. They have changed from war to peace. There is now co-operation for the same object. The old suspicious watchfulness is supplanted by confidence, peace, conscientious work, and, on the whole, a feeling of satisfaction and pleasure that the employers are profiting as well as themselves. Scientific Management has been introduced in almost every department of industry, and in the thirty years in which it has been thriving there has not been a strike in a place where it has been in force, although scores of strikes have occurred in other and similar works.

What Is Scientific Management ?

"It is not any efficiency device for increasing output; it is not a bonus system; it is not a cost system; is not motion study, or time study; it is not unloading a lot of blanks at the goods entrance and saying, 'There is your system, go ahead and use it.' Most people think of it as one of these things. Scientific Management cannot and does not exist until there has been a complete mental revolution on the part of the workmen and the employer, and until this great and complete mental revolution has taken place, scientific management does not exist."

Part of the cost of manufacturing is the cost of material. Another part is the cost of production of the article, and a third is the overhead expense. The difference between the sum of these three and the selling price is the surplus. All labor troubles are due to the division of this surplus. The workmen desire as much as they can get in the form of wages, etc., and the owners as much as they can get in the form of dividends. Under Scientific Management they have ceased combat over the division of this surplus. The result has been a surplus so large that both contenders get more than they ever received before. The workmen get at least 33% more wages, and the company gets larger profits. This is one result of the mental revolution.

Dr. Taylor pointed out forcibly the delusion almost universal among workmen that the division of the surplus in the past has been entirely wrong; that the working men are not getting their proper share of the general profits of capital and labor. Although in some cases it is true, their feelings have been rashly augmented by the labor leaders, newspapers and the public. In an article on "Division of Capital," in the *Atlantic Monthly* of June last, Norman Faig showed their conviction to be wrong. All that the working man can ask for is that the profits that accrue to capitalists should come to the people of the United States. They themselves could not demand all this profit. If it should be divided in the manner suggested there would be thirteen cents per day per man as dividend. It shows conclusively that the hope of the workman does not lie in the division of capital. It lies rather in an increase of output.

The speaker outlined the older type of management where for example, 500 to 1,000 men in perhaps twenty different trades, have acquired their knowledge, not by books, but by observation and by traditional word of mouth. This is just the condition that obtained in the Middle Ages, and still largely obtains. Yet, in spite of lack of progress his trade is the workman's greatest asset. To achieve the best results one realizes that he must get the initiative of his workmen, but one's realization of "soldiering" forces him to the conclusion that to render this initiative the workman must receive a larger remuneration than his competitors. The employer who has the pluck to do this, and to continue doing it, will find that his men will respond to such good treatment. This is the highest type of management under the old system, yet it cannot compete with Scientific Management, for under the latter there is no spontaneity on the part of the workman, but continuous effort. This, because of the new and unheard-of burdens which the management assumes.

The Four Principles

The first of these principles is the gathering-in of the great mass of traditional knowledge held by the workmen; recording it, and reducing it to laws, rules and mathematical formulas. These deductions become of immense assistance is increasing the output. Rule-of-thumb knowledge is replaced by science.

Secondly, it becomes the management's duty to study carefully every man in the plant, his capacities, possibilities and limitations; and to train each to the highest class of work for which he is shown to be fitted—progressive selection and progressive study.

Thirdly, the science and the scientifically trained man are brought together. This is difficult. It can be accomplished only by binding the workman to work by science. This, however, does not cause appreciable trouble. Nine-tenths of the trouble experienced comes from forcing the management and owners to assume *their* burdens.

And, fourthly, a great mass of work formerly done by the workmen is now partly taken over by the management, until the whole is more equally divided. On the management's side there is generally one man for every three workmen.

These principles are deduced from years of study and work under Scientific Management. The system is no longer something which might be found beneficial if tried—it has been well tried—and pays.

The Power of Scientific Management

To illustrate the application of the principles of Scientific Management, Dr. Taylor chose the operation of *shovelling*. A careful study and series of observations in a plant where four hundred to six hundred shovellers were employed resulted in a reduction in the cost of handling iron ore from eight cents per ton to less than our cents, after paying the workmen employed 60% higher wages, establishing a labor office, employing teachers to instruct the men how to scientifically handle a shovel, and timekeepers, etc., to record performances.

Investigation showed that the loads upon shovels under old methods varied from three and a half to thirty-eight pounds. Placed on a scientific basis, a load of about twenty-one pounds to the shovel, proper motions, simple and untiring, the work was now being done by 140 men. Furthermore, investigation into their private affairs showed the workmen to be living better lives, in every way, than before.

Illustrations were also given in the operation of machinery. The speaker claimed that not one in fifty of the machines in the factories of America are speeded accurately. The majority of them are 200% to 400% out, and from two and a half to nine times as much work could be done by them if they were properly adjusted. In the work of the high-class mechanic science is so great a factor that he cannot gain the proper knowledge of himself.

Dr. Taylor instanced, in closing, a case in machine manipulation where mathematicians were confronted with a problem involving twelve unknowns, and struggled with it for eighteen years. Now the problem is solved in twenty seconds on a slide rule taking care of the twelve variables.

"If you are willing to pay the price in time and hard work, things that have through the ages been termed impossibilities, can eventually be solved and put to use for the good of man."

OIL FOR MACADAM ROADS

E. A. James, B.A.Sc.[1]

Automobile traffic has revolutionized our ideas of permanent road construction. Whereas a dozen years ago a well-constructed waterbound macadam road was considered about as permanent a road as could be desired for country traffic, with the constantly increasing use of the high-speed rubber-tired automobile, such roads have in many cases disintegrated faster than they could be maintained.

It has been clearly demonstrated that the bond in ordinary macadam road is insufficient to protect it against the somewhat complex action of the automobile tire traveling at high speed. The dust raised by this class of vehicles is blown entirely off the road and a fresh lot of dust raised, this repeated action resulting in the wearing down of the road surface, in some cases several inches in a single season.

While oiling a road is not considered a permanent remedy for this disintegration, it serves to keep the dust down, thus preventing the next lot of dust being raised, and by this means temporarily preserving the road. There are many varieties of oil on the market for this purpose, some of which are little better than water, while others, having a bituminous base, on the evaporation of the volatile constituents, leave a certain amount of bitumen to act as an aid to the binder in the road. This bituminous residue is increased at each successive application, so that as time passes, the applications may be made fewer and lighter.

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[1] Chief Engineer York Highway Board.

The cost per year of applying oil at current prices, amounts to from eight to fifteen per cent. of the original cost of the road if built by day labor, or from five to ten per cent. if built by contract. The expenditure will be well repaid in the elimination of the dust nuisance and the decreased cost of maintenance, as well as in the increased life of the road.

Cost, per application, of oiling one mile of road, of different widths with varying quantities of material.

Oil, 7½ cents per gallon.

Cost of application, $25.00 per mile.

Width of Road	Square yards per mile	¼ gallon per square yard	½ gallon per square yard	¾ gallon per square yard	1 gallon per square yard	1¼ gallons per square yard
10ft.	5,867	$135	$245	$355	$465	$ 575
12	7,040	157	289	421	553	685
14	8,213	179	333	487	641	795
16	9,387	201	377	554	729	905
18	10,560	223	421	619	817	1,015
20	11,733	235	465	685	905	1,125

Oil, 8½ cents per gallon.

Cost of application, $25.00 per mile.

Width of Road	Square yards per mile	¼ gallon per square yard	½ gallon per square yard	¾ gallon per square yard	1 gallon per square yard	1¼ gallons per square yard
10ft	5,867	$150	$275	$400	$525	$ 650
12	7,040	175	325	475	625	775
14	8,213	200	375	550	725	900
16	9,387	225	425	625	825	1,025
18	10,560	250	475	700	925	1,150
20	11,733	275	525	775	1,025	1,275

Ordinarily the following applications will suffice:—

FIRST YEAR—First application, ½ gallon per square yard.
Second application, ¼ gallon per square yard.

SUBSEQUENT YEARS—Two applications, each ¼ gallon per square yard.

INDIVIDUAL EFFICIENCY[1]

By Norman A. Hill, B.S.[2]

What is *efficiency?* One hears and reads a lot about it these days, but I doubt if one man out of ten can define correctly the technically accepted meaning of the word. This is only natural as it has almost as many meanings as the word "engineer"—which as you know, may be the familiar cognomen for the man who rakes the ashes out of our apartment house boilers or the man who is carrying out the much talked-of international ditch which is to join the Atlantic and the Pacific. Col. Goethels is an enthusiast on efficiency, and in speaking of efficiency engineers says:—

"There are several heads of businesses in this enlightened country who still laugh at the efforts of the efficiency engineers to eliminate waste and supply more needs at less expense.

"They conduct their business in their merry old hit-or-miss manner and are confident that they are doing things correctly as Jim Driscoll was when he left the farm for a steel mill and was sent by the boss to measure a plate with a foot rule.

"Jim came back in the course of an hour or so and reported as follows:—'The plate is the length of the rule and three fingers over, with this piece of cobblestone, and the stem of my pipe, and my foot from here to here, bar the toe-cap.'"

To get back to the point and for our purposes in this paper define efficiency—we will call it the "ratio between the useful work performed by a prime mover and the energy used in producing it." In applying it to the individual then it is the percentage of useful work done in any operation in a unit time, to the energy applied to the doing of it. Now, in speaking of human efficiency we must bring in the element of mental energy expended as well as physical—or elbow-grease effort. The efficiency of a machine is comparatively easy to determine for a machine can't think and its standards of performance can be quite readily found, and speaking of labor saving machine work, Dr. F. W. Taylor answers his critics and obstructionists to efficiency as follows:—

"Two men stood watching a steam shovel at work. With a clatter and a roar the shovel bit into a steep bank, closed on a carload of earth and dumped it on a waiting freight train.

"'It drives me wild,' said the first onlooker, 'to see that monster taking the bread out of good men's mouths. Look at it. Why, it's filling up those flat cars faster than a hundred men with picks and shovels could do it.'

"But the other onlooker shook his head and answered:

"'See here, mister, if it would be better to employ a hundred men with picks and shovels on this job, wouldn't it be better still, by your way of thinking, to employ a thousand men with forks and tablespoons?'"

Since the talk given you by that eminent efficiency expert,

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[1] From paper read before the Engineering Society, Jan. 15th, 1913.

[2] Consulting Engineering and Efficiency Specialist.

Mr. F. B. Gilbreth, last year, you probably have some fairly definite idea of the general principles of scientific management as applied to one phase of the building industry—that very old art of Bricklaying. Now what we want to think about to-day is how to apply those same principles of waste energy elimination to our daily life as engineers and business men. The very first thought is: that little or nothing can be done to increase one's own individual efficiency in college or professional life till the firm determination is made that we will *know ourselves*. Here let me insert an excerpt from a recent article by Arnold Bennett:

"Few people—in fact very few people indeed—ever realize the priceless value of the ancient counsel: 'Know thyself.' It seems so trite, so ordinary. It seems so easy to acquire—this knowledge. Does not every one possess it? Can it not be got by simply sitting down in a chair and yielding to a mood? * * * And yet this knowledge is just about as difficult to acquire as a knowledge of Chinese. Certainly 999 people out of a 1,000 reach the age of sixty before getting the rudiments of it. The majority of us die in almost complete ignorance of it, and none may be said to master it in all its exciting branches. Why, you can choose any of your friends—the wisest of them—and instantly tell him something glaringly obvious about his own character and actions—and be rewarded for your trouble by an indignantly sincere denial! You had noticed it; all his friends had noticed it. But he had not noticed it. Far from having noticed it, he is convinced that it exists only in your malicious imagination. For example, go to a friend whose sense of humor is notoriously imperfect, and say gently to him: 'Your sense of humor is imperfect, my friend,' and see how he will receive the information. So much for the rarity of self-knowledge.

"Self-knowledge is difficult because it demands intellectual honesty. It demands that one shall not blink at the facts, that one shall not hide one's head in the sand, and that one shall not be afraid of anything that one may happen to see in looking around. It is rare because it demands that one shall always be able to distinguish between the man one thinks one ought to be, and the man one actually is. And it is rare because it demands impartial detachment and a certain quality of fine shamelessness—the shamelessness which confesses openly to one's self and finds a legitimate pleasure in confessing. By way of compensation for its difficulty, the pursuit of self-knowledge happens to be one of the most entrancing of all pursuits, as those who have seriously practised it are well aware. Its interest is inexhaustible, and grows steadily."

To get on the track of our commonest faults let us consider three to which I believe that the engineer is particularly subject:

(1) Self-satisfaction.

(2) Laziness, in that there is a disinclination to study anything analytically unless we see its direct bearing on our chosen profession.

(3) Procrastination, the putting off till to-morrow the things we should do to-day.

Now, to give you three concrete examples of these too common faults with us all: The average engineering graduate or undergraduate is full of the first, and often scorns the dirty faced chap in overalls whom he sees oiling an engine, but who probably knows more about steam engineering as an applied science than the college man will know for many a year after cutting his pin feathers in the real work-a-day world.

As to laziness and disinclination to study what seem to be alien subjects: take salesmanship for instance. Few of us realize on leaving college that *salesmanship* is the first thing we need, and the thing we will always need since we are every day selling our services, our brains, our knowledge, and our ability to "deliver the goods" to our employer or client.

As to procrastination, this is so readily acknowledged a fault, that I hardly need dwell on it, but will say that the little motto we see in so many live-wire offices to-day—*Do It Now*—is one of the best little creeds that you can have, for you can never tell, when you postpone, how much you may lose by a forfeited opportunity.

Mr. Dooley says, "Opportunity knocks at every man's dure wanst—on some men's dure it hammers till it breaks down th' dure, an' thin goes in and wakes him up if he's asleep, and afterwards it wurruks f'r him as a night watchman."

Now, to outline a remedy for these most common faults that contribute to individual inefficiency, three obvious steps in the right direction are:

(1) Increase your net worth to yourself by making an absolutely honest self-inventory, not as to your cash capital, anticipated inheritance, pull to land a job or any of the too much counted upon assets, but on your resources and liabilities as a man and an engineer. and what you really do know that is of intrinsic worth to yourself and others. Let me quote here a little stimulus to self analysis that was written by Thomas Dreier, of Boston, one of the cleverest brain merchants of to-day, a man who makes a large income by selling live-wire ideas and inspirational essays, through the *New England Character* magazine:

"You, Mr. Owner of a human life, are the greatest man in the world. The payment of two cents for a stamp places at your service a postal service that encircles the globe.

"For five cents a fifty million dollar subway is offered for your use, and while you ride you are protected by every device discovered by human ingenuity.

"You desire to dash across a continent and the payment of a few dollars, representative, perhaps, of a few days' work—calls billions of dollars, thousands of men, miles of protected track into use for *your* pleasure.

"*You* spend one cent and there comes to you the news of what the world is thinking and doing—that modern Mercury—the triumph of all time, the daily newspaper.

"You wish to hear the voice of a far-away friend and the marvellous network of wires—the master telephone system—is *your* slave. The ocean is tamed and made *your* servant by the monster steamships whose comforts are yours.

"In the fields millions are toiling to supply *you* with food and in the cities countless thousands are serving as ministers to *your* comfort. Fishermen brave the perils of the sea, miners delve deep into the earth, explorers plunge deep into the jungles—all for *you*.

"Alladin with his wonderful lamp, Midas with his touch of gold, Alexander with the world under his feet—their powers were as the powers of children, whereas your power is as the power of a giant. *P.S.—What are you doing to pay for it all?*"

The second step toward increasing your own personal efficiency is to perfect a daily work plan. Pre-arrange your daily and hourly schedule with the idea in mind that you are not going to waste so much time by bluffing yourself into thinking you are doing useful work when you are "soldiering on the job." The very first thing after honesty with yourself and your fellows is to put your mind in order. *Think systematically*—act with true co-ordination. *Imitation* with intelligence, *competition* of the fair play order, *loyalty* to yourself and your employer or client, *concentration* on the task in hand to the exclusion of all trifling or mind wandering, *wage earning as a by-product* and not as the chief object in your work, but an ambitious goal held high as your chief incentive to constant self-improvement. *Pleasure in your work*, *relaxation* and periodic recreation with plenty of hearty, healthy fun-getting exercise, and a consistent and spontaneous *love of the game* of business and life are big factors for success.

It is safe to say that with the average embryo engineer or the man in active practice, by six months' assiduous application to the principles I have tried to set forth he can more than double his output of useful work per day, and when he is through and it is time to play he can enjoy it thoroughly and sleep better every night with the feeling that he *knows* just what he has accomplished and that he is making good and will continue to do so as long as he tries to live up to his efficiency principles as an individual.

As an example of actual results, it is reported by an authority that the installation of scientific management in the office of the Society of Mechanical Engineers in New York City, where no more than twelve persons were employed, saved the society $14,000 a year.

In closing let me give a few good rules for any man, some of them original, some of them appropriated:—

1. Don't tell what you are going to do to a competitor till you have done it.
2. Keep down expenses, but don't be stingy.
3. Make friends—no favorites—in business.
4. Stick to your chosen calling but not to chosen methods. Be original.

5. Make business plans ahead—but don't make them in cast iron.

6. Keep a high vitality, keep cool, and keep sober.

Books of value on this subject are :

"Increasing Human Efficiency in Business," by Walter Dill Scott; "Power of Will," by Frank Channing Haddock; "Business Power," by Frank Channing Haddock; "Efficiency," by Harrington Emerson; "Applied Methods of Scientific Management," by Frederick A. Parkhurst; "Shop Management," by Frederick W. Taylor; "Principles of Scientific Management," by Frederick W. Taylor; "Maximum Production," by C. E. Knoeppel; "Works, Wages and Profit," by H. L. Gantt.

MACADAM ROAD MAINTENANCE

W. Huber, B.A.Sc.[1]

Eternal vigilance is the price of a good permanent macadam road. No matter how much care may be exercised in building it, no matter what the quality of the material used, it can be considered at best but a temporary solution of the good roads problem if at the time of building or immediately thereafter proper provision is not made for its systematic maintenance.

The proper and most economical time to commence the maintenance of this class of road is the day it is opened to traffic. No stone used on road construction is absolutely homogeneous, no bottom is absolutely uniform in its bearing power, and, therefore, no two consecutive sections of road can be considered to have absolutely the same strength. Curious as it may seem, ordinary traffic will sometimes show up small weak spots in a road bottom over which the roller passed showing no indication of their existence, the result of which will probably be a small rut—a rut, perhaps, too small to inconvenience traffic or even to be noticeable to a person driving over it, yet large enough to collect water and soften the surrounding roadway.

Assuming that the road has been properly constructed, i.e., with well compacted sub-grade, properly under-drained, the drains running to free outlets, side-ditches carefully constructed, the road properly crowned and the metal properly bound, the idea of maintenance is to maintain these ideal conditions. As the stability of the new road is in so large a measure influenced by the facilities for drainage supplied, so will the durability of the road depend largely upon the care with which these drainage facilities are maintained. The principal work of the man on maintenance will, therefore, be to keep the drainage both above and under the road as perfect as when it was first constructed. This includes keeping the road well crowned, the sides clean and sloping to the ditches, the side-ditches open and their outlets free, drain and culvert openings clean, and ruts and depressions filled immediately they become noticeable.

The amount of work required in such maintenance will depend, of course, on several factors—quality of material used in construction, nature and amount of traffic, nature of soil, grades, climate, weather, tc.

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[1] Chief Assistant Engineer, York County.

The system of maintenance should be as simple as possible and not more than two men should be concerned in the work of any one section, viz., the road superintendent and the man actually engaged in the work. Regarding the latter, it is true, as in many other cases, that it pays to have a first-class man, even at a rate of pay higher than paid to one of mediocre ability. He must be a man who can understand the principles on which roads are built for permanency, and who can reason for himself. A man at this work will often be working for days at a time without direct supervision, and he must be a man who can be trusted to do his work and who can also be trusted to find work for himself. A man of this description will save the road superintendent many gray hairs, and will leave him time to devote to his heavier problems.

The equipment required for road maintenance other than complete re-surfacing is simple—a pick, a shovel, a wheel-barrow, a fairly heavy tamping-iron and a pail, being all that is required. There should also be deposited at short intervals on the road-side, small piles of crushed stone and grit. For small repairs the stone may be somewhat finer than the regulation two-inch size used in construction. From one to one and a half-inch will be found most satisfactory. The grit for repair work should be selected for its cementing quality, even more than in construction work. For this work it will be found profitable to secure and store a car of the very best grit obtainable, even at a higher price and freight rate than ordinary grit.

The length of road which one man can properly look after varies with local conditions, but ordinarily a single man can keep from four to six miles in good repair. If it is found that he cannot keep up with the work, his section should be shortened, rather than another man added, as it is found the most economical work is done by men working singly.

The best time for examining the entire length of a section is just after a rain. This will show up all ruts and other depressions, and also any obstructions or lack of grade in side ditches, drains and culverts.

The best method for filling ruts and low spots in the surface is to pick the stone loose in and for several inches around the depression, add a little fresh stone and grit, wet it, and tamp thoroughly. It may be found that traffic will disarrange the stone somewhat, but if it is gone over a few times at intervals of a day or so it will be found to have set and become an integral part of the road, and, if the work has been carefully done, indistinguishable from the remainder of the road. These small depressions should be remedied as soon as they appear, remembering that each one forms a basin for the collection and retention of water which in turns softens the road. This work all resolves itself into an attempt to keep the surface drainage perfect.

Another cause of trouble in macadam roads is the allowing of the earth sides to become cut up and become higher than the edge of the stone, thus impounding water that would otherwise run off. These earth shoulders should be kept trimmed below the level of the stone. In this connection an occasional trip over the road with a split-log or plank drag will be found economical. This will necessitate the hiring of a team for an occasional day, but the expenditure will be well justified, and it will be found that the longer this practice is continued, the less dragging will be required, as the surface of the earth shoulder will become hard, smooth and impervious to water and able to support traffic almost as well as the stone section. In fact, this part of the road, where this method has been followed, is in dry weather often preferable for driving to the macadam section.

The remaining most important part of the maintenance man's work is the keeping of all ditches and drain and culvert outlets open. This work will be heaviest in the spring and fall, when ditches tend to become clogged with leaves and other debris. During the winter special pains must be taken to keep all these water-courses in first-class working order, bearing in mind that the principal idea in winter is to have a course ready for the water as soon as the snow starts to melt. In this as in other work, it is easier and cheaper to anticipate trouble than to remedy it after it occurs.

These few points, then, comprise what seem to be the essential features in Macadam Road Maintenance, and if they can be put any more briefly, may be stated as follows:

Start maintenacne as soon as the road is built.

Put a good man at the work.

Keep both stone and earth sections smooth and properly crowned.

Remove every obstruction to water running off and from under the road both in summer and winter.

And lastly, and most important of all—keep eternally at it.

W. Almon Hare, '99, president of the Hare Engineering Co., Limited, Toronto, has returned from a summer spent in Europe.

F. H. Sykes, '05, has been appointed chief examiner of plans for the city architects' department, Toronto. Mr. Sykes was previously assistant structural engineer in this department.

H. P. Rust, '01, has been appointed engineer-in-charge of one of the largest hydro-electric developments in the West, by the Great Western Power Co., in San Francisco.

Wm. Snaith, '07, who was associated with Frank Barber, bridge and civil engineer, Toronto, is secretary-treasurer of the Thor Iron Works, Limited, a new corporation equipped for the fabrication of steel tank and plate work, steel trusses and light structural work.

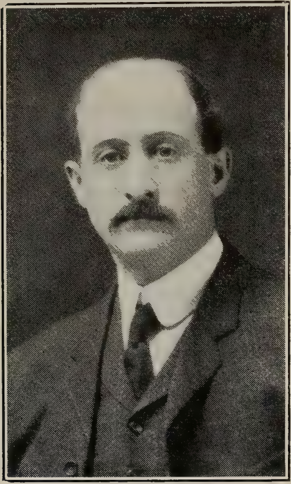
V. C. Thomas, '08, is in the manufacture of hydraulic turbines with Wellman Seaver-Morgan Co., of Cleveland, O.

A. R. Robertson, '08, until recently with the Canada Foundry Co., is now with McGregor & McIntyre, Toronto.

BIOGRAPHY

Eugene W. Stern, '84

We are too modest about the accomplishments of School men and particularly of those across the border. No matter how many visits to Gotham we may have had to our credit, each succeeding trip with its first glimpses of massive buildings, bridges, etc., creates, in no small degree, wonder and amazement, and let it be said hereafter, admiration for the prominent part that some of our School men have played in that great city's development.



One of these men is Eugene W. Stern, '84.

He was born in Toronto, August 20th, 1865, and Jarvis Collegiate Institute had a share in preparing him for entrance into the School of Practical Science in 1881. At the end of the first year, and with one of the prizes in engineering already to his credit, he chained the summer of '82 on township surveys in the Nipissing District. The following summer was also spent by him in the Nip., as instrument man on township survey work, and the second prize in Engineering dangled from his belt. Then in April, 1884, he graduated, taking with him his third and the year's first prize, indicating his enviable position at the head of the class list.

The Northern and Pacific Junction Railway, now a part of the Grand Trunk railway system, employed him as rodman on construction in the vicinity of Cyprus, Ont., until November of that year, and until November of the following year as assistant engineer, having in his charge the construction of twelve miles of road, with headquarters at Novar, in the Parry Sound district.

He was back at S.P.S. during the following year as fellow in engineering, and has in this respect distinction of being the first assistant to Principal Galbraith in the branch of work designated in the curriculum by the word "Engineering."

From August, '86, to March, '87, he was employed as draftsman in the office of the Passaic Rolling Mills, Paterson, N.J., working on the shop plans of the Washington Bridge over Harlem River, a 500-foot plate girder arch construction, and also on the shop plans of various railroad bridges, draw spans, turn tables, and so on. For the following six months he was with the Grand Avenue Railway Co., of Kansas City, Mo., as assistant engineer on the construction of their cable railway.

Four and a half years were then spent by Mr. Stern with the Chicago Bridge and Iron Company, of Chicago, previously the Kansas City Bridge and Iron Company, the greater part of this time being spent as assistant engineer designing railroads and highway bridges, including the bridge over the Msississippi River at Winona, Minn., also considerable roof and sub-structure work.

Back to Missouri in February, 1892, Mr. Stern held the position of chief engineer for the Koken Iron Works, St. Louis, for over six years in full charge of the design and supervision of the construction of many city buildings, roofs and bridges, the St. Louis Coliseum being one of them.

In July, 1898, he went to New York. He became chief engineer of the Jackson Architectural Iron Works, in complete charge of design and superintending the construction of the steel work of many high office and loft buildings.

For the last eleven years Mr. Stern has been a consulting engineer, making a specialty of buildings and foundations. He has, during this period, designed or supervised the constructional work of nearly one hundred buildings, costing about thirty million dollars, the contract price of the engineer's work of these amounting to about six million dollars. Among these are: the Terminal Station at Hoboken, N.J., for the Delaware, Lackawanna & Western Railway; also passenger station at Scranton, Pa., and Ferry House at 23rd Street, New York, for the same railway; New Ferry House for Erie Railway, at 23rd Street; B. Altman & Co.'s store at Fifth Avenue and 35th Street; National Park Bank; Travelers' Insurance Com pany, Hartford; New York Evening Post; State Liberty and Supreme Court Building, Hartford; Physicians' Office Building, 12 storeys; residence for J. P. Morgan, Jr.; Guaranty Trust Company's Building, 8 storeys, on pneumatic caisson foundations; Auerbach candy factory, 11 storeys; Architects' Office Building, 20 storeys; Cotton Exchange Building, 21 storeys, on pneumatic caissons. He has also been associated on the construction of the thirty-two storey City Investment Building, also on pneumatic caisson foundations; Union Passenger Station, Chattanooga, Tenn.; and the State Armory, Hartford, Conn.

Mr. Stern has been a member of the American Society of Civil Engineers since 1897, and of the Canadian Society of Civil Engineers since April, 1909. He is secretary of the American Institute of Consulting Engineers. He has also been, since its inception, a staunch member of the Engineering Society, and has contributed several articles to its publications.

The world well knows why we are proud of Eugene W. Stern, '84.

G. G. Powell, '02, has been recommended by Works Commissioner Harris to the position of deputy city engineer for Toronto and the recommendation has been approved by the city council.

J. H. Curzon, '11, is chief draughtsman for T. Martin, '96, divisional engineer for C.P.R. at Moose Jaw, Sask.

M. B. Watson, '10, and T. A. Fargey, '09, have entered the employ of the Toronto Electric Light Co.

PNEUMATIC CAISSONS FOR TALL BUILDINGS

By O. W. Ross, B.A.Sc.

In every big city, owing to the prevailing prices in real estate every inch of available space must be utilized, with the result that the foundations of a new building must be very close on either side with those of the adjoining buildings. The buildings must also be as lofty as possible and consequently, the increase in the erection of skyscrapers in the past few years has been made in the face of grave and increasing engineering difficulties. The study of the laying of the foundations of almost any large building will bring out what these problems are, and how the resourcefulness of engineering contractors has been developed.

The preparations involved in the erection of the modern skyscraper are enormous. The foundations must often be laid to bed rock through many feet of quicksand and water bearing strata which is probably already heavily loaded by an adjoining building. In digging, water and soft mud may be encountered, but a few feet below the street level. Were this soft mud pumped out or removed by any of the old time methods, more of this fluid material would enter the excavation from either side and the adjoining structures would settle and later collapse. It is the work of the laying of these foundations that has allied science and necessity in the working out of the new problems.

When one carries iron and steel construction below the surface, whether on land or water, he is at once confronted with the question of corrosion. In so far as that construction is of a temporary character, this may be disregarded. But when it is proposed to use material in permanent works, then the question becomes a very serious one. However, the opinion seems to be fairly well founded that if the concurrent action of water and atmospheric oxygen can be prevented, corrosion will not take place or will proceed at quite a slow rate and engineers now seek to exclude the air or the water.

Compressed air has solved the problem as it has solved many others in the development of construction. Compressed air made the rapid building of steel structures possible by the rivetting hammer. But the application of the principle underground is more crafty. The pneumatic caisson process in conjunction with the Moran Air Lock is the way that compressed air has been applied to these difficult foundation problems.

Perhaps it would be as well to state that there are two distinct forms of caissons. There is a caisson open at the top, whose sides, when it is sunk in position, emerge above the water level, and which is either provided with a water-tight bottom or is carried down, by being weighted at the top and having a cutting edge round the bottom, into a water-tight stratum, aided frequently by excavation inside. There is also a bottomless caisson serving as a sort of diving bell, in which men can work when compressed air is introduced to keep out the water in proportion to the depth below the water level, which is gradually carried down to an adequately firm foundation by excavating at the bottom of the caisson and building up a foundation on the top of its roof as it descends. Where foundations have to be carried down to a considerable depth in water bearing strata, or through the alluvial bed of a river, to reach a hard stratum, bottomless caissons sunk by excavating under compressed air are used.

The caisson, considered as an aid to sinking foundations through wet material, consists of an inverted box having a sectional shape according to the work it is intended to do. The principle is, that so long as the air pressure in this box is maintained equal to or slightly above the water pressure upon the outside, down to the lower edge of the caisson, water cannot enter. Work is carried on in the chamber formed by the caisson, in many cases the work of laying the masonry on top of the caisson being carried on at the same time. As excavations advance the caisson sinks, the air pressure in the inside being reduced slightly until the dead weight of the caisson itself, and the masonry on its top, are sufficient to overcome the frictional grip or resistance due to the bearing upon the outside surface of the material it is passing through.

These bottomless caissons afford a procedure applying to building foundations which has demonstrated itself as applicable to practically all conditions. The certainty of success has made them a strong favorite with engineers, although the expense is very great.

History of Pneumatic Processes

Since the year 1894, the pneumatic process has been used extensively in laying foundations for buildings but it is only lately that the necessity for it has been fully appreciated, and that it has been carried to a great degree of refinement.

The method of compressed air for enabling operations to be carried on under water in the form of building a foundation is merely a modification of the diving bell. Papin, an eminent physicist, born at Blois in 1647, was the man responsible for this idea of employing a continued supply of compressed air thereby enabling workmen to build under a large diving bell. The use of compressed air was demonstrated more forcibly in 1779 by Coulomb when he presented to the Paris Academy of Science a paper detailing a plan for executing all sorts of operations under water by the use of compressed air. The method and apparatus used by him then was very similar to that in use at the present time.

A patent for a device for sinking tubular shafts through earth and water, by means of compressed air, was taken out in England, in the year 1831, by Earl Dundonald, then Lord Cochrane. He used an air lock very much like the ones of to-day and he placed it, in a similar position, at the top of the main shaft. He was, at the time of his invention, engaged in tunneling under the Thames, and he applied this compressed air system to this work and also to other similar enterprises. Another man, also an Englishman, by the name of Bush, in 1841, devised a plan for sinking foundations by means of compressed air and he likewise patented his device. In 1850 a bridge was to be constructed at Mayenne, and C. P. fawn Muller, a German, with a device very similar to that used by Cochrane and Bush, undertook to sink the foundations by the use of compressed air. He failed, however, as his plan was not executed, but it brought to light the usefulness of this method to some extent.

The application of the compressed air method, which was similar to a diving bell, as has been said, to a cylinder forced down by undermining was first made, about 1841, at Chalons for working a coal seam rendered inaccessible by the infiltrations of the Loire. After having begun the shaft by beating down a cylindrical lining of sheet iron about 60 feet, 40 inches in diameter, it occured to the engineer, M. Triger, to cover over the top of the cylinder, and by forcing air in to drive out the water and admit the workmen. He did this because, when he reached a layer of coarse gravel, he could force the tube no farther, so he brought compressed air into play. An air chamber was formed at the top with double doors, serving as a sort of lock for the passage in and out of the cylinder of men and materials without giving an outlet to the compressed air. The pressure he used was never greater than two atmospheres. The water was discharged through a small tube, into which, several feet from the bottom, a jet of air was allowed to enter, thus diminishing the specific gravity of the column till it was rapidly blown out. In 1845, M. Triger sank another cylinder 6 feet in diameter to a depth of 82 feet, in the same way, and suggested the employment of the method for the foundations of bridges.

The first bridge foundations of this kind were carried out in the years 1851-52, at the Rochester bridge on the Midway, which has masonry piers each supported on 14 cylinders, 6 feet 11 inches in diameter, filled with concrete. Having begun with the vacuum process, which Dr. Potts of England, has the credit of inventing, till on alighting on old foundations it proved useless, Mr. Hughes M. Inst. C. E., conceived the notion of reversing the current of air and sinking the cylinders by the help of compressed air. The success of this method recalled to mind earlier suggestions in the same direction such as the patent of Lord Cochrane for excavating foundations by compressed air and also the success in stopping the rush of water into the Thames Tunnel by forcing in air. It was now realized that the many advantages of the compressed air process would cause it to entirely supersede the vacuum process and the pneumatic process of to-day is really the compressed air process.

The foundations of the piers of the Kehl Bridge were accomplished by a combination of the principles of the compressed air process, the sinking of a pier by its own weight, and the coffer dam system. As the bed of the Rhine at Kehl consists of large masses of gravel liable to be disturbed to a depth of 55 feet below water level, it was deemed advisable to carry the foundations down 70 feet below low water. It was there that the first pneumatic caissons were employed, there being three shafts to each caisson.

In America the pneumatic process was first used in 1852 for a drawbridge over the Harlem River at Third Avenue, where a number of cast iron cylinders about four feet in diameter were sunk to support each pier. Sometimes where cylinders of small diameter have to be used the excavations are extended beyond the cylinders at the bottom, and filled with concrete to give a greater bearing surface; this plan was adopted at the Harlem Bridge. In 1856 and 1860 Pneumatic Pile Foundations were constructed in South Carolina. At the St. Louis Bridge in the year 1870, foundations were carried to a greater depth than had ever been previously attained. The depth reached 109 feet 8½ inches, in this case has not yet been exceeded. Another interesting case of the use of Pneumatic caissons, is the Brooklyn Bridge. Here the excavating was done by a scoop dredger when possible. When hard soil was met with the shafts were shut and the excavation performed by manual labor under compressed air. Ever since certain New York contractors decided to bring over a French engineer, and learn all he could teach them about compressed air methods, the system has improved. They have universally adopted the pneumatic system and have introduced many improvements.

Pneumatic caissons have been used mostly in New York City, and they are a necessity there in the building of foundations for skyscrapers. The extreme height of some of the structures and the consequent imposition of tremendous loads is only one part of the problem, because this merely requires that piers be sunk to hard pan or bed rock. The chief difficulty connects itself with the presence of water and when this is associated with sand, we have the great problem which confronts foundation engineers. The difficulty does not centre itself upon securing penetration but upon the preservation of the foundations of adjacent structures. If the water is removed in large quantities from the immediate sight, this may at once entail a settlement of an adjacent foundation. It is this consideration, perhaps, more than any other, which has brought the pneumatic caisson into such general use in the sinking of foundations for large buildings. During the past few years the procedure has been almost revolutionized because the application of it has been so necessary and extensive to great foundation problems.

General Principles of Caissons

The fundamental principle underlying the compressed air or pneumatic process is simply that the atmospheric pressure of 15 lbs. per square inch will support a column of water, in a tube or pipe from which the air has been exhausted, about 34 feet high, when the open end is immersed in a body of water, or 1 lb. will balance a column 27 inches high. Practically these heights cannot be supported, as a perfect vacuum is almost impossible. But it is commonly stated that we must have 1 lb. pressure for every 2¼ feet of depth below the water surface, to keep the water out of the working chamber. The actual pressure is 15 lbs. more, as we have to balance a like pressure on the surfact of the water outside the caisson; this excess is constant for all depths. So that if the depth below the water is 90 feet, the actual air pressure in the caisson is about 45 + 15 = 60 lbs. The uplifting effect is, however, only 45 lbs.

Ordinarily, it becomes necessary to reduce the air pressure in the caisson very materially at times in order to allow the caisson to sink; at other times, however, it is necessary to cease altogether, adding weight to the caisson to prevent a continuous or too rapid sinking. This, of course, depends both upon the actual resistance at the lower or cutting edge of the caisson which may or may not be very great, and upon the frictional resistance on the exterior surface of the caisson and the structure upon it. It is, therefore, in general, better to have as little frictional resistance on the side surfaces as practicable, and to provide as great a direct resistance at or a little above the cutting edge as is consistent with economy and convenience of construction and subsequent ease of prosecuting the work.

As the working chamber should be practically air-tight, some special means of entering and leaving the working chamber must be provided. The air lock has this object in view, and wherever it is planned or whatever its design it must be an airtight box with two doors, both opened toward the greatest pressure—that is toward the air chamber or some air tight channel or shaft communicating with it. However, as the air lock in a special form will be dealt with later on, it is not necessary to describe it here. Strong and tight iron shafts are built into the caisson, and should always reach well above the surface of the water; the main shaft through which the men enter and leave need not be over four feet in diameter. This is made in sections, which are bolted together through internal flanges, between which rubber bands or some soft and impervious substance is placed, so as to render the joint air tight. Ordinary, red lead worked up with short strands of ordinary lampwick will answer every purpose; it is easily obtained and applied.

A smaller shaft, not over 18 inches or 2 feet in diameter for letting concrete or other material into the working chambers is used also. It is better to have at least two of these; they are provided with a door at the top and bottom only, the entire shaft being an air lock. Pipes from 4 to 6 inches are also built into the caisson—the larger for connection with the air hose and force pump for water, the smaller for use in blowing out the material.

Compressed air is rarely, if ever, required until the caisson rests firmly on the bed of the river, or in its proper position for the foundation. As soon as it rests this way the men go in by means of the air lock and see that everything is in good working order and then the caisson is ready for business. Now, if everything is ready below, a gang or shift of-men pass into the lock and thence into the caisson and the work of excavating the material in the caisson is commenced. One thing can be relied on, so long as the air pressure required by the depth is maintained, the water will not rise above the extreme lowest line of the cutting edge of the caisson, and in sinking through some materials, water has to be pumped into the caisson in order to carry on the work. If the caisson is not heavily weighted before the air pressure is put on, it is liable to lift and careen.

The effect on men working in compressed air is very interesting and instructive. It has created a disease which will be described at another place in this article. For this reason the men must be carefully selected and great precautions taken for their comfort and care. A code of signals is always used by which the men in the caisson can communicate their wants to those above. All oscillation in the pressure should be avoided as the immediate effect of reducing the air pressure even by only a few pounds is to set up a dense fog. A complete outfit of the machinery needed should be at hand as much time and money are lost and great inconvenience caused by the want of them. This gives vaguely some idea of the essential points in connection with pneumatic caissons and the actual construction and operation of them should now be examined.

Underpinning Adjoining Buildings

As has been said in the introduction, the removing of material close to adjoining buildings will often cause them to settle and later collapse. The constructors to whom is entrusted the responsibility both of planning and doing the work of excavating near another

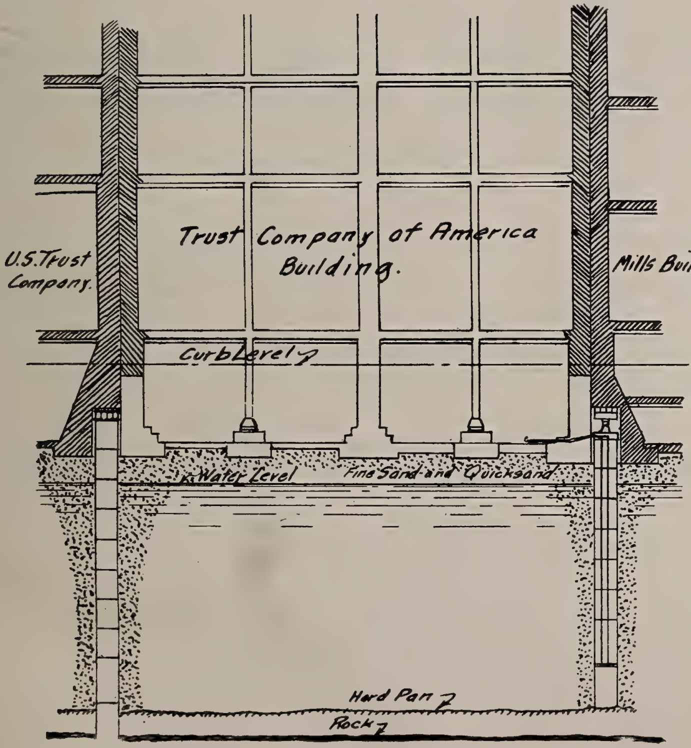


Fig. 1. Showing how Pneumatic Caissons were used in underpinning the buildings adjacent to The Trust Company of America Building while the old building was being wrecked.

building have solved these problems by employing the caisson in conjunction with the Moran Air Lock.

The principle of the air lock was used for the underpinning of the adjoining buildings as well as for part of the main work of the laying of the foundations for the building of the trust Company of America on Wall Street, New York. Fig. 1 shows how the work was begun even while the old building was being wrecked. Niches about 5 feet above the cellar floor and 5 feet wide were cut in the walls of the adjoining buildings with electric and steam drills at intervals of about every 6 to 9 feet. These were carried downward through the old foundation, and through the sand under the foundation until the water line was struck. Then a six foot length of riveted steel pipe, 36 inches in diameter, was jacked down into the sand, thereby employing the weight of the building in constructing the new underpinning. A downward opening door was installed at the top of this length, a second length was bolted to the first, and then the second downward opening door was installed, completing the miniature air lock.

As shown in the figure, compressed air was supplied to the bottom chamber, and the work pushed lower and lower through quicksand or hardpan, as successive lengths of pipe were bolted to the top and material excavated. When rock was reached, the entire cylinder was filled with concrete, the steel pipe remained, and when steel beams were placed as shown in the left side of the sketch, the underpinning at that point was completed.[1]

Twenty-seven concrete piers constituted the foundation work proper under the Trust Company of America Building. The remarkable speed with which these piers were sunk to bed rock was made possible mainly from this one fact. The air lock used allowed the material excavated in the caisson to be hoisted to the open air in one continuous haul, being handled but once in transferring from bottom of the caisson up to the dumping place, generally a truck.

In Fig. 2 is shown the four boom traveler derrick, which was equipped with four double drum hoisting engines, and which effectively covered the entire area. It served to place the caissons, one of which weighed 20 tons, and was 14 x 31 x 8 feet high at their proper location. It also hoisted men and material in and out of the twenty-seven working chambers. Fig. 2 also shows the air lock in place near the top of the picture. A man was placed on the ground as gauge tender, to keep the pressure steady for the convenience of the men in the working chamber, and another man at the air lock to communicate signals between the excavators and the engineers.

The piers were sunk through soft soil to bed rock without weakening the adjoining buildings. They were sunk end to end with only 12 inch spaces between, and the chain of piers around the entire site was made perfect by welding or bonding between the ends of the piers. This kept the water from entering either the basement or the sub-basement of the Trust Company of America building.

This solid wall type of bonded foundations constructed has this great advantage. The piers in the centre of the lot can generally be sunk without the expense of the compressed air method, for there is little danger of any water seeping in from the outside, and therefore of weakening the other buildings.

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[1] Sc. Am. Supp. Apr. 20, 1907, Fds. Problems in N.Y.C.M., Ripley.

Caisson Construction and Operation

General Make-up and Size of Caissons

Foundations which are constructed by aid of compressed air generally employ a cylindrical caisson of iron, divided into two unequal parts by a horizontal partition, the upper part, which is the larger, is the caisson proper. It is a cofferdam within which the masonry is built in the open air. The lower part, which is filled with compressed air, and within which the excavation is carried on, is called the working chamber. It is furnished with one or two shafts made of boiler iron, which are surmounted with an iron chamber called the air chamber. Adjoining this is the "equilibrium" chamber, or air lock, through which workmen and materials must enter. A pipe from the compressing engine furnishes the air

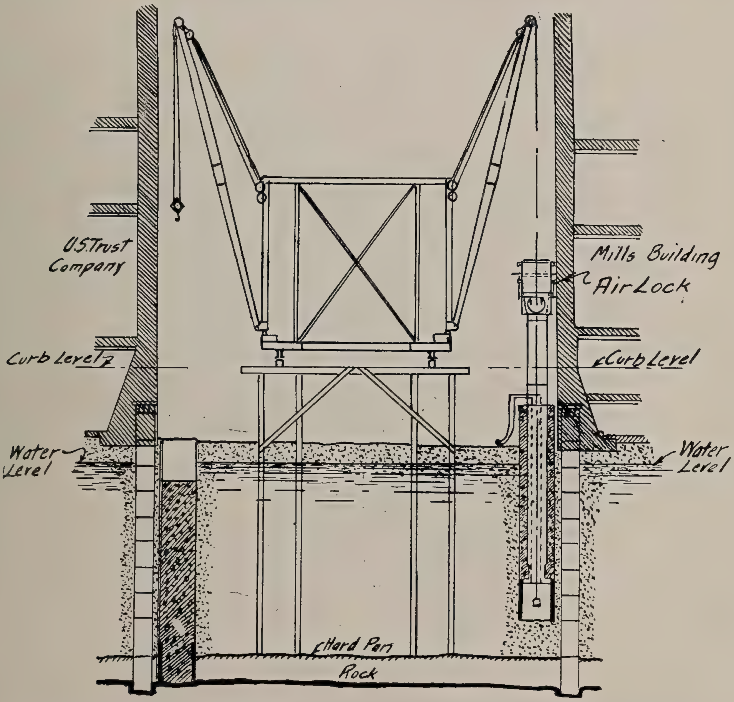
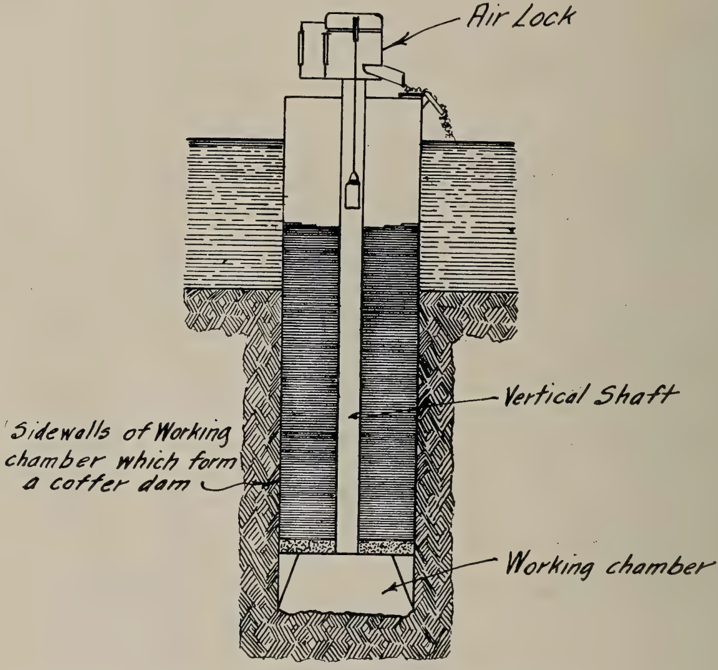


Fig. 2. Showing the air lock in position on the Pneumatic Caissons used for the main foundations of The Trust Company of America Building.

chamber with compressed air. The air chamber and air lock are generally located above the highest level of the water, in order to insure the escape of workmen in case of accident. Fig. 3 exhibits the relative position of the various parts as was the design of A. Heinerchiedt in the year 1880. We draw from this that the essential parts of the pneumatic caisson are really the working chamber, the vertical shafts and the air lock and the side walls of the working chamber which are carried up to form a coffer dam.

The usual method of making a caisson is to build it first, with the roof or deck about 6 or 7 feet from the cutting edge—the site having being first excavated to the water level—work in the open by cheap labor, of course, being cheaper than excavation in the air chamber by high priced sand hogs, with the cost of the compressor plant, etc., in addition.



No. 3. Relative position of various parts of Pneumatic Caisson. Design of A. Heinerchiedt in 1880.

For ordinary caissons, great variation has existed, and still exists, in the design and construction, some engineers using very thick timber side walks with a timber roof or deck 10 or 12 feet thick, others reducing the thickness of the timber roof to 3 feet, while others again use plain concrete or reinforced concrete and employ timber only for forms, while a few build the whole caisson and cofferdam of steel and cast iron. A good example of steel caissons was the Mutual Life building where the sizes ran from 3 ft. diameter for underpinning cast iron caissons, to 8 x 22 ft. for main caissons. These caissons are fairly represented by the two adjoining figures. Fig. 4 shows a typical caisson, employed in constructing the foundation for a large building, fairly started, and Fig. 5 shows the same caisson when it has reached bed rock and is about ready for the concrete in the air chamber.[1]

Several contractors in New York have recently tried sinking caissons of concrete, using timber for forms and removing the forms as soon as possible. Theoretically, this method is the cheapest of all, but practically it has been found that it paid to leave an outside shell of timber on to permit the sinking to proceed continuously, which is not possible when removable forms are used, necessitating a cessation of sinking for a day or so, sometimes several times for each caisson, to permit the concrete to harden before being subjected to the friction of the ground.

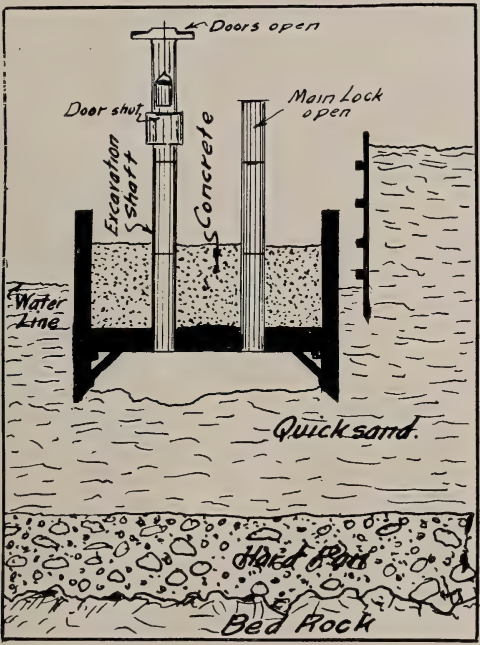


Fig. 4. A Typical Caisson, fairly begun.

The removal of forms required considerable labor, sometimes high priced, as in the case where iron angles were used and the forms were held together by means of steel bolts, which gave the iron unions a chance to insist upon the bolts being put in and taken out by iron erectors.

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[1] Pneumatic Caissons, T. K. Thomson. Sc. Am., Supp. Oct. 10, 1908, p, 234.

All wooden caissons should have an outside tongued and grooved sheeting of 2in. or 3in. plank laid vertically to avoid friction on long horizontal joints. Most contractors, however, use plank with a calking edge instead of tongued and grooved, and then calk with oakum.

For small caissons, say from 5 to 12 feet square, there should be a horizontal wall of 8in. or 10in. timbers from the cutting edge to the roof instead of the plank sheeting, properly braced at the corners, and inside of this there should be a 12in. x 12in. belt course under the roof. One solid course of 12in. x 12in. timbers is ample for the roof or deck, and if concrete is placed on the deck as fast as the caisson is sunk, the plank sheeting will be sufficient for the side walls above the deck, with light horizontal waling pieces spaced about 5 feet apart vertically.

For large boxes, up to 30 feet wide, 27 inch sides, below the deck, have been used; that is, 3in. plank against the 12 x 12 horizontals, inside of which were placed a wall of 12 x 12 posts, about half of which extended from the cutting edge to the roof and the rest projected from 2 to 6 feet above the deck, while the corner posts and an intermediate about every 15 feet apart were extended to the top of the cofferdam, properly spliced at the joints.

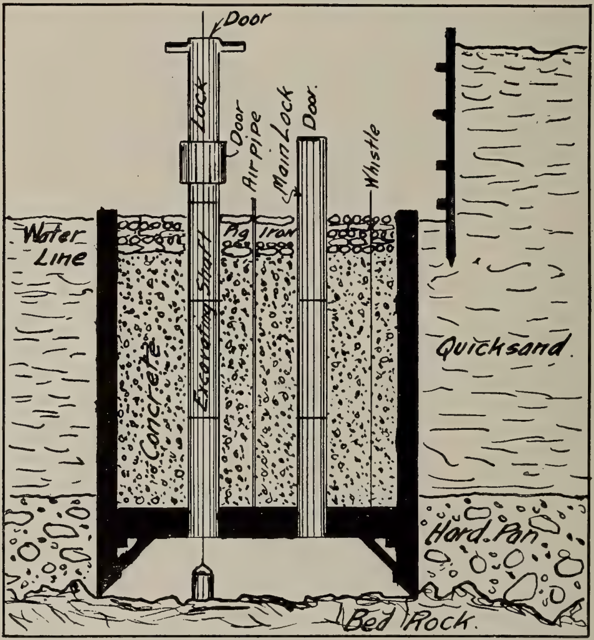

Fig. 5. The Caisson at Bed Rock, ready for concrete in air chamber.

Above the deck, horizontal 12 x 12 inch walings placed from 3 to 5 feet apart vertically were placed outside of the posts, the sheeting being spiked to the walings.

In the concrete were placed in the cofferdam on top of the caisson as fast as the caisson was sunk, all the bracing above the deck could be removed as the concrete reached the bottom of the brace, or omitted altogether in some places, but it is often necessary to keep the concrete 20 to 30 feet lower than the surface of the water in order to prevent the caisson from becoming too heavy, when very heavy cofferdam bracing will be required to withstand the hydrostatic head.

In sinking the first caisson for a New York City skyscraper, the Manhattan Life Building, steel caissons were used, on top of which brick work was built, but it was found that the friction broke the new mortar, thus pulling the brickwork away from the caisson. In any case, the cofferdam should be very securely attached to the caisson, the necessity of which was proved in a river caisson, where the clay was taken out of the air chamber and dumped over the side of the cofferdam, to which it adhered and broke the whole cofferdam, 106 feet long, away from the caisson.

Many small New York caissons have been built with wooden sides and a 2 inch plank "form" under the roof, on which 2 feet of concrete has been laid and allowed to set for a couple of days, after which the form was removed and the concrete continued. At first, forms were also used instead of cofferdams for the sides above the roof, but after this scheme had been used for 3 or 4 buildings it was abandoned as not economical in practice.

In these caissons, sometimes the steel shafts were left in, and in other cases collapsible steel shafts or wooden forms for the shafts were used and then removed. Removing or leaving out the steel shaft in a small caisson is very risky and has been attended by accidents, where the caisson has broken in two owing to greater pressure on one side of the jutting edge than the other.

Steel caissons have been used a great deal in the past, but are not used a great deal in New York now, except perhaps for circular caissons, especially where of very small diameter. The advantage of using steel for round caissons up to 10 or 12 feet in diameter, consists in the rapidity with which the light sections of cofferdam can be bolted on and filled with concrete, the time saved often being enough to pay for the extra cost of the material. Another advantage is the ease with which they can be made watertight.

Small caissons for underpinning purposes are made from 30 to 36 inches diameter, of cast iron or built up steel plates. A good plan is to use steel cutting edge sections and make the upper sections of cast iron, using 1½ to 2 inch metal. In underpinning the adjoining buildings to the extension of the Mutual Life Building, in 1900, twenty-six of the small caissons from 60 to 80 feet deep were used.

Much difference of opinion exists as to the proper form of cutting edge, which, as might be inferred, is the bottom of the caisson, the idea being that it cuts its way into the underlying material, though, as we have seen, it is often necessary to excavate under the cutting edge itself. Many strive to obtain a knife edge (for the cutting edge) by means of steel plates and angles; while in many cases an 8 inch channel laid flat has served the purpose. The knife edge, is of course, ideal, but it is very expensive, and where it is really needed is almost sure to become bent and distorted, in which case it is far worse than no cutting edge at all.

Twenty-seven inch inside diameter is the smallest pneumatic caisson that men have worked in comfortably, but even then they were cramped somewhat for room, and 33 inch inside diameter or 36 inch outside has been found to be a much better size.

For the main caissons of a new building, anything under 6 feet in diameter is unsatisfactory, as there is not sufficient room for the men and bucket, and besides it is hard to keep small caissons plumb and in line.

In the above only those caissons in which the roof is left in place have been considered, but there are many places where it is desired to sink the caisson shell with a temporary roof, and, of course, a temporary weight, where, for instance, the base of the column must be set below the surface of the ground before the main part of the cellar is excavated. This has been done in a number of cases in New York in recent years where there are from three to four floors below the street level, both for the purpose of saving time by allowing the erection of the steel work to commence before the cellar is excavated, and also in order that the steel work and concrete floors may be used, as the cellar excavation proceeds, to obtain sufficient bracing for the side caissons, which are usually only 6 to 8 feet wide, forming a wall around the building sometimes 60 or 70 feet below the street line, and are entirely too light to withstand the enormous water and earth pressure without the horizontal bracing afforded by the floors.

The material of the caisson proper and of the cofferdams may be of wood or steel; the shaft will be of steel or some material which can be made air-tight when the air is under pressure. The concrete is first placed on the roof of the working chamber, within the cofferdam but outside the shaft. The upward prolongation of the shaft wall, of the cofferdam and of the hollow cylinder of concrete resting on the roof of the working chamber proceed somewhat together. When sinking to the final depths has been completed, concrete is laid in the working chamber and carried on up the shaft to the surface.[1]

(*To be continued*)

S. E. M. Henderson, '00, is in charge of the switchboard department of the Canadian General Electric Co., Peterborough. C. E. Sisson, '05, is in charge of transformer work for the same company.

J. H. Caster, '07, until recently with the Canadian General Electric Co., of Peterborough, is now in the employ of the Toronto Hydro Electric system.

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[1] Modern Steel Caissons, J. F. Stringer. Ir. Trd. Rev. Jan. 6 1910 page 103.

APPLIED SCIENCE

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EDITORIAL

The executive has announced the twenty-fourth annual dinner of the Engineering Society to be held at McConkey's on the evening of February 13th, 1913. Invitations will be mailed within the next few days.

THE SCHOOL DINNER

This year's dinner will be a return to the genuinely enthusiastic event of years ago. We have been leaving our latitude in many respects. Last year's dinner showed the undergraduate attendance to be as follows, by years:—

1. From a total of 265 members, 40 were present—15.1%
2. From a total of 216 members, 33 were present—15.3%
3. From a total of 154 members, 8 were present—5.55%
4. From a total of 163 members, 69 were present—42.3%

798 150 18.75%

A careful investigation made clear the fact that previous executives have devoted much attention to the careful compilation of their guest lists at the expense of provision of features of interest and enjoyment to the undergraduates. Dinners of recent years have been important in their own way. Efforts to advance the interests of the School, by bringing together guests and staff, have been successful in that conversational enlightenment and benefit have been the result.

As for the undergraduate, his was not the opportunity of chatting with the men of prominence who assembled at the guest table, nor even with the graduates generally, who held interests in common with themselves, or with members of the staff. From an educative point of view there was little or nothing which he could acquire as he was not in the mood, or which he could not acquire by reading at some future date. The student does not attend the School dinner for the same reason that he attends lectures, and if there is not recreative enjoyment for him the dinner naturally loses his support.

It is similar with the graduate. In other societies and on other occasions he hears or reads all that there is of value in the after dinner speech, and if this event does not savor of old time School spirit and enthusiasm he entertains a feeling akin to Goldsmith's Traveler, and his interest wanders elsewhere.

It is evident from observation and analysis that the School dinner is no longer *the* School dinner when it does not retain the interest of the graduate and much less so in the case of the student. The function can be of much greater value to the Faculty of Applied Science and Engineering by having for its primary object a cementation of its undergraduate and graduate bodies. An event it should be such that interest will not flag nor enthusiasm fade in the midst of a series of after dinner speeches.

This year's dinner will be one entirely for School men. It is to be full of entertaining features for student, graduate, staff member and visitor, and its chief function is to be a revival of School spirit.

THE QUESTION OF CERAMICS

The Canadian Clay Products Manufacturers' Association at its recent convention in Toronto, devoted a great deal of discussion to the best ways and means of presenting their great need for technical knowledge bearing upon the raw materials employed in the production of brick, tile, etc., and upon the mechanical methods in vogue in their manufacture. This has been a much discussed subject at every annual meeting of the Association for years, and the great necessity for the establishment without further delay of an educational department devoted to ceramics led its members to approach President Falconer for relief.

In earlier copies of Applied Science (Jan. 1910, and Jan. 1911) mention has been made of a similar movement six years ago, which occasioned the appointment, by the Minister of Education, of a special committee to investigate what has been done in the United States towards the development of technical training in ceramics. There followed the committee's report, including in detail a description of the department of ceramics in the University of Ohio, at Columbus, together with proposals for similar requirements if such a course were to be established in the University of Toronto. The Faculty Council tendered its approval, as did also the University Senate, but the Board of Governors arrested the progress of the movement because of insufficient room and funds.

Of great importance to the clay industries of Canada and to the University is the work which Mr. J. Keele, '93, is doing for the Geological Survey of Canada in the laboratories of the Faculty at present. Mr. Keele's paper in the last issue of APPLIED SCIENCE shows well his knowledge of the country's resourceful clay beds. He is the best informed man in the Dominion on the subject, and the results of his experimental work here on the great variety of clays and shales —samples gathered from all parts of the country—will be of utmost value.

Another vital asset to the clay products men in their movement is the fact that there is at the present time sufficient space available for the housing of machinery and equipment necessarily belonging to such a department. The east wing of the Chemistry and Mining Building, until recently occupied as a museum, has been vacated, the specimens having been removed to their new and spacious home on Bloor Street. The wing would provide a fair working space for present needs although it is less than two-thirds as extensive as the department at Columbus, as may be noted from a comparison of the space (1) at the University of Ohio with that (II) as proposed for the University of Toronto.

	I	II
Glass work	285 sq. ft.	480 sq. ft.
Ceramic Physical Laboratory	527	....
Instructor's Laboratory	283	320
Balance room	153	...
Ceramic Chemical Laboratory	1,469	...
Lecture room	1,094	960
Museum and Office	698	660
Storage	895	780
Main work room	1,933	1,100
Pottery machinery	1,074	1,500
Machinery room	698	...
Motor room	256	...
Kiln room	1,444	...
Private room for staff	...	320
Metallurgy	...	320

The Canadian Clay Products Manufacturers' Association, at its initial session, appointed a special committee to confer with representatives from the staff of the Faculty of Applied Science, and to formulate a plan of procedure. Assured of the co-operative spirit in the Faculty towards an endeavor to inaugurate such a course, a delegation of over seventy, representing all the clay provinces of the Dominion, waited upon President Falconer, and its leading men presented their request. A communication from a manufacturer of brick machinery was also read, offering to donate to any Canadian university or school, of which the Association might approve, a complete laboratory equipment consisting of a brick machine, grinding pans, automatic cutter, dies, etc., that would establish a course. Dean Galbraith voiced his sympathy with the movement, informing the delegation that his annual reports for many years have contained an intimation of the great need for a course of instruction for the benefit of the clay industry. Dr. Ellis outlined the work and report of the special committee previously mentioned, he himself having been a member.

The president in reply expressed his interest in their agitation and his apprehension of the need of technical training for men proposing to devote their lives to the industry. The vital question he stated was that of funds. No university in America was carrying on its work at so low an expenditure per student as the University of Toronto, and the situation was becoming graver yearly. He intimated to the delegation that they should not delay in bringing their matter to the attention of the Board of Governors and of the Provincial Government, and confirmed the Dean's statement that when the funds for such a course were once available, the Association might be assured that great care would be exercised in outlining and maintaining an efficient course in ceramics.

The members of the Association were well pleased with the evidences of co-operative feeling prevalent in the University, with the reception given them by President Falconer, and likewise by several members of the Board of Governors, whom they approached later.

SOME IMPORTANT EXPERIMENTAL WORK

Mr. J. Keele, '93, who with Professor Heinrich Ries, of Cornell University, prepared a report entitled "The Clay and Shale Deposits of Western Canada," mentioned in "Applied "Science" for September, is at present engaged in a series of laboratory experiments in the metallurgical laboratories of the Faculty of Applied Science and Engineering. Several tons of samples were brought by Mr. Keele to Toronto, and are being tested for their utilitarian values in the various branches of clay products manufacture.

Work of this nature had not before been undertaken in Canada, the government having on other occasions recoursed to the facilities offered in the laboratories of Cornell University. This departure from previous custom is an important item for the University of Toronto and particularly for the School.

In Mr. Keele, the Geological Branch has, without doubt, the best informed man in the Dominion upon the country's clay resources, and his knowledge not only of the clay, shale and sand-stone beds, but of qualities and usefulness of their contents, has placed him upon a pedestal as an authority whose word and work is of immense value to the country.

The school is also fortunate in being able to claim him as one of its graduates, and as one who delights in devoting his spare moments toward the instruction of others. The classes in metallurgy, architecture and mining have benefited greatly by Mr. Keele's interesting talks on the subjects varying on formations, from the natural to the scientific.

The work which the Geological Surveys Branch is carrying out in our laboratories will have a great influence upon the future of the clay industry in Canada, and the University of Toronto is winning distinction as being the seat of the important investigations.

LECTURES ON VECTOR ALGEBRA

At the request of Dean Galbraith, the President has invited Dr. Alexander Macfarlane, F.R.S.E., to give a short course of lectures on the subject "Vector Algebra."

The utility of vector ideas and of graphical constructions based on vectors is familiar to all engineers. The engineer can make no progress without means of dealing with forces, stresses, velocities, acelerations, not to speak of numerous kinds of vectors in electrical engineering.

The more familiar facts, however, relate to processes analogous to addition and subtraction; thus a large field is left involving multiplication of vectors and more complicated processes which is largely *terra incognita* to the engineer.

Dr. Macfarlane has made the analytical study of such relations his special field and is in fact president of an international association for the promotion of such studies.

It is hoped that this invitation from the University may be useful to members of the staff and graduates as well as to any senior students who may wish to attend.

The lectures will be given during the week beginning February 10th, at a place and time to be arranged.

CANADIAN CLUB OF NEW YORK.

Dean Galbraith attended the eighth annual banquet of the Canadian Club of New York, and as usual, his presence was hailed with delight. Indeed, among the great men of America few are so universally respected and loved as John Galbraith, and as he took his seat at the guest table among fifty statesmen, presidents of banks and railroads, and like officials, many realized that there were few even in that wonderful array of brains and capabilities who could compare their achievements to those of the man who founded and built up the School of Practical Science.

Some idea of the calibre of other guests may be gathered from the following list of guests, a stronger and more important group of men having never before graced a Canadian banquet in the United States: Sir Edmund Walker, president Canadian Bank of Commerce; Professor Willis L. Moore, Department of Agriculture, Washington; Mr. Frank Vanderlip, president National City Bank, New York; Mr. William C. Brown, president New York Central Lines; Mr. James G. Cannon, president Fourth National Bank, New York; Captain Albert Gleaves, U.S.N., Commandant Brooklyn Navy Yard; Mr. David R. Forgan, president National City Bank, Chicago; Hon. A. S. Goodeve, Railway Commissioner, Ottawa; Mr. Ralph Peters, president Long Island Railroad; Dr. Daniel M. Gordon, principal Queen's University, Kingston; Mr. Lewis L. Clark, president American Exchange National Bank; Rear-Admiral Bradley A. Fiske, U.S.N., commanding First Division, U.S. Atlantic fleet; Sir Robert Williams, former partner of the late Cecil Rhodes, South Africa; and a score of others. The Right Hon. R. L. Borden and Mr. E. J. Chamberlain, president G.T.R., expressed their regrets at being unable to attend.

The president of the Canadian Club of New York, T. Kennard Thomson, '86, had the honor of presiding and calling upon the following for speeches: Col. the Hon. Sam Hughes, Minister of Militia and Defence, Ottawa; Prof. Willis L. Moore, Dean Galbraith, Sir Edmund Walker, William C. Brown, David R. Forgan, Principal Gordon, Hon. A. S. Goodeve, and Mr. C. W. Barron.

Ernest Thompson Seton gave the members a rare treat, as did also Mrs. A. A. Watts, wife of one of the members of the club, who recited "The Spell of the Yukon" and "Grin," by Robert W. Service.

On the same day Mr. Thomson gave a luncheon to about fifty of the guests at the Engineers' Club of New York, at which a score of excellent speeches were made. Among them were those of John A. Stewart, representing the proposed celebration of one hundred years of peace; Hon. Sir Alexandre LaCoste, Ottawa; Mr. C. W. Barron, owner and publisher of "The Wall Street Journal" and "Boston News Bureau"; Charles Warren Hunt, secretary American Society of Civil Engineers, and the past-presidents of the Canadian Club of New York, together with the presidents of other Canadian Clubs.

CLASS '14 DINNER

A very successful dinner was held by the third year at the St. Charles, in Toronto, on Wednesday evening, December 18th, 1912. Over one hundred and twenty-five of the class were in attendance. The speech list was enlivened by selections by the Science Octette and by the School's "Symphony Orchestra," conducted by Mr. Foote.

The first toast of the evening was proposed by Mr. H. J. MacKenzie to "Our Alma Mater," and responded to by Dean Galbraith. The Dean based his speech largely upon the value of the general training, to any man preparing himself for any profession, adding in his usual good style from his store of reminiscences, incidents in the past life of the School as amusing as they were historical. He referred particularly to a squirrel hunting expedition in which our Professor Wright was pronounced by an Indian band of spectators a very good hunter indeed.

Mr. R. G. Matthews proposed the toast to the Faculty of Applied Science. In replying Professor Wright made reference to the status of the School men in industrial communities, emphasizing the widespread effect of the thorough knowledge and training acquired by men at S.P.S. The toast to the "Year '14" was proposed by Mr. F. C. Mechin and replied to by Mr. W. J. Smither, after which Mr. G. M. Smyth introduced "The Engineering Profession," to which President Ritchie of the Engineering Society responded.

A toast to athletics was very heartily responded to by Mr. T. R. Loudon at the intimation of Mr. E. B. O'Connor. The renown of many of the members of the year in athletics is enviable, and Mr. Loudon's remarks created a volume of applause.

The evening's entertainment and pleasure were brought to a close by a vote of thanks moved by Professor Wright and seconded by Dean Galbraith for the very efficient manner in which the event had been conducted, pronouncing great credit due to the president of the year, "Dutch" Macpherson, and his executive, for the success of the event.

"THE TOIKE-OIKE CLUB" OF MONTREAL.

The graduates in Montreal having grown desirous of a shorter and more concise name for their association, have chosen the above to designate them and their official representative body in future. The name is well chosen in that undergraduates temporarily in the city on business or pleasure need entertain no feelings of dubiety as to it being a club for graduates alone.

A meeting is to be held in Montreal, at Cooper's Restaurant on the evening of January 28th. The annual meeting of the Canadian Society of Civil Engineers will bring many School men into Montreal and those who can should attend the "Toike-Oike" smoker that evening, to meet as many as possible of the School men in Montreal.

RE-UNION OF CLASS '09

The class of 1909, of which T. Harold Crosby is president and G. Ross Workman, Secretary, purposes holding its first re-union dinner on February 14th. The date was set between that of the School dinner (February 13th) and the Queens-Varsity Intercollegiate hockey game at Arena Gardens (February 15th). It is understood that these events are being included in the programme for the re-union.

The place where the dinner will be held on St. Valentine's night has not been decided upon. The members of the class have been notified of the date only, and their support, which will be evidenced by the returned postcards enclosed in their circulars will largely determine the nature of the proceedings.

THESES FOR DEGREE OF B.A.Sc.

The following is a complete list of theses presented by men of the fourth year for the degree of Bachelor of Applied Science. The bracketted figure following each name designates the course the candidate is following, thus: (1) Civil Engineering; (2) Mining Engineering; (3) Mechanical Engineering; (4) Architecture; (5) Analytical and Applied Chemistry; (6) Chemical Engineering; (7) Electrical Engineering; (8) Metallurgical Engineering.

Candidate.	Title of Thesis.
Adams, O. F. (7)	Power Factor Measurement.
Allen, R. J. (7)	Electrical Ignition.
Alport, F. (1)	Design of a Power Plant.
Anderson, A. S. (3)	Boiler Furnaces.
Avery, C. R. (1)	Water Purification.
Baldwin, L. C. M. (4)	Design of Theatre.
Beatty, F. W. (1)	Precise Levelling.
Beatty, W. B. (1)	Longitude.
Bell, C. A. (2)	Explosives—The Nature of the Break.
Bell, R. S. (7)	Electrification of Railways.
Binns, R. E. (2)	The Classification of Ores.
Black, B. S. (1)	Modern Country Highways.
Blain, D. (1)	Plate Girders.
Bonter, E. R. (7)	Practical Application of Induction Motors.
Brereton, L. R. (7)	Electric Pumping.
Brock, W. M. (1)	Brick, the Ideal Wall Material.
Brown, B. (4)	Design of a Railway Station.
Buchanan, T. R. (2)	The Effect of Impurities on the Electrolytic Assay of Lead.
Buchanan, W. B. (7)	Rotary Converters—Their Application and Efficiency.
Burrows, B. H. A. (3)	Improvements in the Modern Locomotive.
Cain, E. T. (3)	Alloy Steel.
Caldwell, W. B. (2)	The Manufacture of Ferro-Alloys in the Electric Furnace.
Cameron, O. L. (1)	Water Purification.
Campbell, L. L. (1)	Preservation of Railway Ties.
Carmichael R. M. (3)	Turbine Pumps.
Carrie, G. M. (1)	Dust Prevention.
Clark, H. A. (8)	An Investigation of Ferro-Alloys by the Electric Furnace.
Clarkson, G. E. (6)	Dyestuffs.
Clegg, B. D. (3)	Low Pressure Steam Turbines.
Coleman, J. H. (7)	The Transformer—Design and Types.
Cook, G. M. (1)	Fireproof Building Construction.

Coombs, J. A. (1)	Railway Tubes and Tunnels.
Coon, B. R. (4)	Design of a Bank Building.
Curtis, W. T. (2)	The Breaking of a Rock by Explosives.
Dates, A. J. (1)	Concrete as a Fireproofing.
Davison, H. D. (3)	Steam Boilers.
Deitch, E. L. (7)	Automatic Motor Starting.
DeLaporte, A. V. (5)	The Utilization of Certain Commercial Wastes.
Diamond, R. W. (2)	An Investigation of the Hydro-Metallurgy of Copper.
Duncan, W. G. (7)	High Tension Insulators.
Fleming, D. H. (1)	The Septic Method of Sewage Disposal.
Flint, T. R. C. (7)	Street Illumination.
Foote, F. F. (3)	The Design and Construction of Cupolas as Used in the Founding of Grey Iron.
Galbraith, J. S. (1)	Slow Sand Filtration with Special Reference to the Toronto Plant.
Garnham, W. H. (2)	The Bearing of Different Sampling Methods on the Absolute Assay Value of an Ore.
German, A. M. (1)	The Disposal of Municipal Refuse..
Goodman, H. M. (1)	Irrigation—With Special References to Dominion Government Work in Saskatchewan.
Gray, A. G. (1)	Modern Track Standards.
Gray, A. J. (3)	The Design and Construction of Foundry Cupolas.
Gray, E. R. (1)	Design and Construction of Sewers.
Hadcock, J. P. (7)	Commutation.
Hall, H. G. (7)	Lightning Protection.
Hamilton, J. R. (1)	Concrete Piles, Types, Manufacture and Driving.
Harris, H. C. (7)	Automatic Control of Direct Current Motors
Hawley, H. A. (1)	Aesthetics in Design of Concrete Arches.
Hayman, A. W. (1)	Design and Construction of Bridge Piers.
Hearn, R. L. (1)	Electric Subway Systems.
Heinonen, H. J. (1)	A Discussion on Slow Sand Filtration and Sterilization of Water.
Henry, R. A. (3)	Gas Producers, Dealing with Their Construction, Action and Use.
Hill, T. A. (7)	Single Phase Electric Traction.
Holden, O. (1)	Street Railway Trackwork.
Howard, J. T. (1)	Concrete Roads.
Howlett, T. F. (7)	Insulation of Electrical Machines.
Ireson, E. T. (1)	Canalization of Rivers.
Junkin, R. L. (1)	Plane-Table Topography, as Practised by the Geological Survey of Canada in Ontario.
Kelly, S. S. (7)	Transformer Cores and Core Losses.
Kerr, A. E. (7)	Interpole Motors and their Industrial Application.
Kilmer, C. E. (7)	Electric Power Line Troubles.
Laing, J. S. (1)	Costkeeping.
Leslie, A. (7)	Electrical Distributing Systems.

Lillie, G. L. (7)	Distribution for Electric Railways.
Livingston, H. D. (4)	Design of a Colonial Residence.
Lytle, L. B. (7)	Electric Traction Systems.
MacKenzie, H. A. (7)	Storage Batteries.
MacKenzie, H. R. (1)	Reinforced Concrete Abutments.
Maclachlan, K. S. (6)	The Modification of Fats.
MacPherson, A. R. (1)	Concrete Pavements.
MacTavish, W. H. (1)	Topographic Surveying as Practised by the Department of Militia and Defence.
McCarthy, T. V. (1)	Mechanical Filtration of Water.
McConnell, R. S. (4)	Design of a Collegiate Institute.
McFaul, W. L. (1)	Sewage Disposal Plants for Small Communities.
Mickleborough, K. F. (1)	Methods of Sewage Filtration.
Mickler, G. J. (7)	Rates of the Sale of Electrical Energy.
Millman, N. C. (1)	Wharves and Mooring Piers.
Moore, T. R. (1)	Irrigation.
Mulqueen, F. J. (1)	The Sao Paulo Electric Co.'s Power Plant at Soracaba, Brazil.
Murdie, W. C. (1)	Topography.
Mutch, D. A. S. (8)	A Metallurgical Engineer's Report on a Possible Undertaking.
Newton, K. L. (8)	An Investigation of the Hydro-Metallurgy of Copper.
Oke, W. V. (1)	Some Reinforced Concrete Systems.
Otto, C. J. (5)	Some Mixtures of Unknown Compositions Occurring in the Products of Wood Distillation.
Parkinson, N. F. (1)	Concrete Arches.
Peart, J. W. (7)	Unit Switch System of Multiple Control.
Perron, J. E. (1)	Tunnelling.
Phillips, J. J. (1)	Fabrification of Structural Steel.
Quail, H. C. (1)	The Corrosion and Preservation of Iron and Steel with Particular Reference to Structural Steel.
Ratz, E. G. (7)	Electric Locomotives.
Relyea, P. J. (6)	The Utilization of Atmospheric Nitrogen for the Production of Nitric Oxide and Other Compounds.
Riddell, J. M. (1)	Methods of Base Line Measurement.
Ritchie, J. E. (1)	Timber Preservation.
Robertson, C. S. (1)	Sludge Disposal.
Roblin, H. L. (1)	Roadbed from a Maintenance Point of View.
Rothery, L. W. (3)	Steam Turbine Blading.
Rous, C. C. (7)	Water Wheel Governors.
Russell, C. H. (7)	Three Phase Transformers.
Scarlett, A. A. (7)	Internal Combination Engines as Applied to Turbine Propulsion.
Sewell, L. (1)	Plane Table Topography.
Seymour, H. L. (1)	Sewage Disposal by the Method of Live Earth Beds.

Sharp, M. C. (7)	A System of Illumination for a Manufacturing Plant.
Shaw, K. E. (3)	Beet Sugar House Machinery.
Sims, F. R. (3)	Diesel Oil Engines, their Principle of Operation, Thermal and Mechancial Efficiency.
Sinclair, D. G. (2)	The Effect of Impurities on the Electrolytic Assay of Lead.
Soper, R. W. (4)	Design of a University Theatre.
Spellman, W. A. (1)	Roadways.
Strathy, J. M. (7)	High Speed Dynamo Electrical Machinery.
Sutherland, D. (1)	Sewage Disposal.
Tasker, R. (1)	Bituminous Pavements.
Thompson, W. K. (2)	The Bearing of Different Sampling Methods on the Absolute Assay Value of an Ore.
Thompson, D. J. M.(1)	The Corrosion of Iron and Steel.
Thomson, D. J. (7)	Insulators for High Tension Transmission Lines.
Torrance, T. E. (7)	Street Lighting.
Trow, R. M. (2)	Efficiency in Methods of Screen Analysis.
Ure, W. G. (1)	The Flat Slab System of Reinforced Concrete Floor Construction.
VonGunten, C. F. (1)	Electrolysis.
Watts, R. E. (3)	Carburation and Carburetors for Oil Engines.
Webster, C. A. (3)	Centrifugal Fans.
Webster, H. (4)	Design of a School of Architecture.
Weir, D. H. (1)	Improvement and Maintenance of the Highways of Ontario.
Whately, H. E. (7)	Single Phase Series Commutating Railway Motor.
Winters, W. S. (1)	Water Supply and Purification.
Wood, R. F. B. (1)	Caissons.
Wright, A. J. (7)	High Voltage Protective Devices.
Yorke, L. P. (7)	Electric Furnace Temperature Measurements.
Young, R. B. (7)	Mercury Vapor Apparatus.

WHAT OUR GRADUATES ARE DOING

A. E. MacGregor, '10, is in the employ of the Board of Works, London, Ont.

F. T. Nichol, '10, is in Winnipeg managing the branch in that city of C. W. Noble & Co.

A. W. Lamont, '09, for several years with the Canadian Westinghouse Co., in Winnipeg, will join the staff of the Toronto Hydro-Electric System on Feb. 15th.

E. H. Phillips, '00, and W. M. Stewart, '06, are members of the engineering and surveying firm of Phillips, Stewart & Lee, Saskatoon, Sask.

A. G. Wheler, '11, is engineering salesman for Edgar M. Moore & Co., Pittsburg, Pa.

W. J. Walker, '07, is division engineer for Transcontinental Railway at Hearst, Ont.

T. J. Cunerty, '11, is with the Westinghouse Electric & Mfg Co., at East Pittsburg, in the publicity department.

R. W. E. Loucks, '09, is a member of the firm of Brown & Loucks (T. W. Brown, '06), engaged in general engineering, surveying and contracting with offices at 410 Drinkle Bldg., Saskatoon, Sask.

C. W. Dill, '91, resides in Winnipeg, where he has become associated with the National Paving Co., as general manager.

E. A. Neville, '09, is a member of the firm of Neville & Stewart, engineers and surveyors, 428 Vancouver Block, Vancouver, B.C.

H. B. Thompson, '10, is with the Dominion Bridge Co., in the Toronto office.

A. H. Munro, '10, is at Campbellford, Ont., on Trent Valley Canal construction.

J. B. Minns, '07, is with the Canadian General Electric Co., as sales engineer in the Winnipeg office.

L. G. Ireland, '07, formerly with the Midland Construction Co., has accepted a position with the Hydro Electric Power Commission at Brantford, Ont.

A. H. Hull, '06, for several years with Smith, Kerry & Chace, in their Toronto office, is now in the employ of the Hydro Electric Power Commission.

R. L. Harrison, '06, is engineer-in-charge of the Toronto Eastern Railway, and resides at Oshawa, Ont.

F. W. Burnham, '04, has recently accepted a position with the Canadian Westinghouse Co., Hamilton.

M. B. Heebner, '11, is with the Foundation Co., as assistant engineer on the Pitt River bridge, main line C.P.R., at Coquitlam. B.C.

A. M. West, '08, is assistant engineer of North Vancouver.

A. F. Macallum, '93, city engineer of Hamilton, was recently elected vice-president of the American Society of Municipal Improvements.

F. W. Baldwin, '06, is associated with Graham Bell in the manufacture of hydroplanes that have a speed of 55 miles per hour.

E. F. Hinch, '10, is resident engineer of construction with the Toronto Power Co. at Port Credit, Ont.

S. Young, '11, is with the Saskatchewan Government in the Department of Public Works, Regina.

E. A. Jamieson, '10, is resident engineer for the C.P.R. on the erection of the Pitt River Bridge, main line, Coquitlam, B.C.

J. H. Ryckman, '06, until recently with the Chicago, Rock Island and Pacific Ry. Co., has accepted the appointment to the staff of the Strauss Bascule Bridge Co., Chicago.

W. D. Walcott, '11, is now in Toronto in the employ of the Canada Foundry Co.

W. M. Philp, '09, until recently with the Canadian General Electric Co., Peterborough, has resigned to accept a similar position with the General Electric Co. at Schenectady, N.Y.

C. H. Rogers, '06, is manager of the Peterborough Canoe Co., at Peterborough, Ont.

DIRECTORY OF THE ALUMNI

Giving each month, in alphabetical order, the location of a number of the graduates. The entire list will be reviewed in the twelve issues beginning November 1912.

The graduates will confer a favor by advising us of any and all instances where the list is not up-to-date. Addresses unknown, or no longer correct, are hard to eliminate entirely from our records. If graduates will see that the information given about *themselves* is exactly as it should be, and that that concerning their class mates is also correct to the best of their knowledge, the department will soon be most reliable.

B (*Continued*)

Brown, G. L., '93, resides in Morrisburg, Ont., and is engaged in civil engineering and surveying.

Brown, L. L., '95, is superintendent of the Foundation Company, New York.

Brown, T. D., '04, is in Calgary, Alta., western representative for the Canadian Fairbanks-Morse Co.

Brown, J. A., '07, is with Routly & Summers, in their branch office at Porcupine, Ont.

Brown, E. I., '08. His home address is Paris, Ont. We do not know his professional engagement.

Brown, C. E., '09, is in Hamilton, Ont., with the Canadian Westinghouse Company.

Brown, H., '11, whose home is in Port Sidney, has been in Calgary during the summer.

Browne, E. W., '09, His present address in unknown to us. He was in Hamilton last year.

Browne, M. O., '10, is in Toronto, but we do not know what his present employment is.

Bryce, W. F. M., '08, is in the office of the city engineer, Ottawa, Ont.

Buchan, P. H., '08, is assistant engineer, construction department, British Columbia Electric Railway, Vancouver.

Buchanan, J. A., '09, is on survey work in the West. His home address is in Comber, Ont.

Burke, M. A., '90, deceased.

Bucke, W. A., '94, is manager of the Toronto district office of the Canadian General Electric Co.

Bunnell, A. E. K., '06, is engineer in charge of the construction on the Lake Erie & Northern Railway, from Brantford to Galt.

Burd, J. H., '03, has been engaged in surveying and civil engineering work in Sudbury and other places. We have no address at present.

Burgess, E. L., '03, is with the topographical surveys branch, Department of the Interior, Ottawa.

Burgess, J. R., '10, is inspector at the plant of the Algoma Steel Co., Sault Ste. Marie, for the Robert W. Hunt Co.

Burns, D., '83, is a member of the teaching staff of the Carnegie Institute of Technology, Pittsburgh, Pa.

Burns, J. C., '87, deceased.

Burns, J. E., '09, is managing editor of " Referendex," Toronto.

Burnham, F. W., '04, is in the engineering department of the Canadian Westinghouse Co., Hamilton.

Burnham, N. G., H., '10, is in charge of a hydrographic survey party on the Red River Navigation Survey for Manitoba Hydrographic Survey Commission.

Burnside, J. T., '99, is in Montreal, where he is engaged in engineering work for the Harbour Commission.

Burwash, L. T., '96, is Government mining engineer and recorder for the Yukon, with headquarters at White Horse.

Burwash, N. A., '03, is with Speight and Van Nostrand, surveyors and engineers, Toronto.

Bush, C. E., '07, after spending the summer on topographical work in the West, has just returned to Toronto.

Byam, F. M., '06, is in the employ of McGregor & McIntyre, Toronto, as chief engineer.

C

Cain, E. T., '11, is taking a post graduate course in engineering this year

Calder, J. W., '04, is withthe Hydro-

Electric Power Commission at Port Arthur and Fort William, Ont.

Cale, W. C., '10, is with the Stone and Webster Engineering Corporation, as engineer on transmission line construction, at Keokuk, Iowa.

Cameron, N. C., '04, is associated with the Dominion Engineering and Construction Co., of Montreal.

Cameron, A., '06, is in Winnipeg, Man., in the employ of the Vulcan Iron Works, Limited.

Cameron, M. G., '09, who has been engaged on the Trent Valley Canal, near Peterboro, has no address with us at present.

Cameron, C. S., '11, has Beaverton, Ont., for his home address.

Campbell, A. D., '10, is in Cobalt, Ont., as mining engineer for the O'Brien Mines.

Campbell, A. J., '04, his home in Collingwood, Ont. We do not know the nature of the work upon which he is employed.

Campbell, A. M., '04, was, until recently, in Chilliwack, B. C. His address has changed recently, and we cannot supply it.

Campbell, W. G., '02, who resides in Toronto, is engaged in railway contracting, at present in the vicinity of Perth, Ont.

Campbell, A. R., '02. We have no address at present.

Campbell, R. J., '95, was with the Western Electric Company of Chicago, but latest advice indicates that he is no longer there.

Campbell, G. M., '96, is superintendent of the power apparatus shops of the Western Electric Co., at Riverside, Ill.

Campbell, W. C., '05, whose home is at Keene, Ontario, is in the West, engaged in mining engineering.

Campbell, N. A., '08, is chief chemist for the Canada Cement Co., at Calgary.

Campbell, R. A., '09, is in the employ of the Tagona Light and Power Co., at Sault Ste. Marie, Ont.

Campbell, A. W., '06, in with the Hydro-Electric Power Commission, Toronto.

Campbell, J. E., '08, has no address with us at present, except his home address at Coldstream, Ont.

Campbell, C. D., '11, is town engineer of Galt, Ontario.

Canniff, C. M., '88, is managing editor of the "Engineer Clubman," a journal in the interests of the members of the Engineers' Club of Toronto.

Carey, B., '89, has no address with us at present.

Carlyle, W. M., '10, is secretary-treasurer of Carlyle and Beck, concrete contractors, Toronto.

Carmichael, C. G., '02, deceased.

Carpenter, H. S., '97, is superintendent of Highways, Department of Public Works, Regina.

Carroll, A. M., '08, is a member of the engineering staff of Routly & Summers, Haileybury, Ont.

Carroll, M. J., '06, is with the Department of the Interior, Ottawa, in the Topographical Survey Branch.

Carscallen, H. R., '08, is on hydrographic work in the West, with P. M. Sander, at Calgary.

Carson, W. R., '05, is mechanical engineer in charge of plant and construction, Grasselli Chemical Co., Cleveland, O.

Carter, W. E. H., '98, is a member of the firm of consulting mining engineers, Carter and Smith, Toronto.

Carter, J. H., '07, until recently with the Canadian General Electric Co., Peterboro, is now with the Hydro-Electric Power Commission.

Caudwell, N. S., '10, is in his second year in law, Osgoode Hall.

Cavell, E., '07, last year a member of the staff department of drawing, has no professional address with us. His home is in this city.

Chace, W. G., '01, is a member of the firm of Smith, Kerry and Chace, Toronto.

Chadwick, R. E. C., '06, is now Eastern manager of the Foundation Company, Limited, with offices in Montreal.

Chadwick, W. W., '11, resides in Hamilton, Ont. We are not informed as to how he is employed.

Challen, G., '08, is at 25 Coombs St., Southbridge, Mass, We do not know his professional work.

Challies, J. B., '04, is hydraulic engineer, department of the Interior, Ottawa.

Chalmers, W. J., '89, is assistant engineer Ohio River Improvement, U. S. Government, and resides at Vanport, Pa.

Chalmers, J., 94', is structural engineer, Department of Public Works, Edmonton.

Chandler, R. B., '11, is in the office of the City engineer, Saskatoon, Sask.

Charlesworth, L. C., '93, resides in Edmonton, and is director of Surveys for the Province of Alberta.